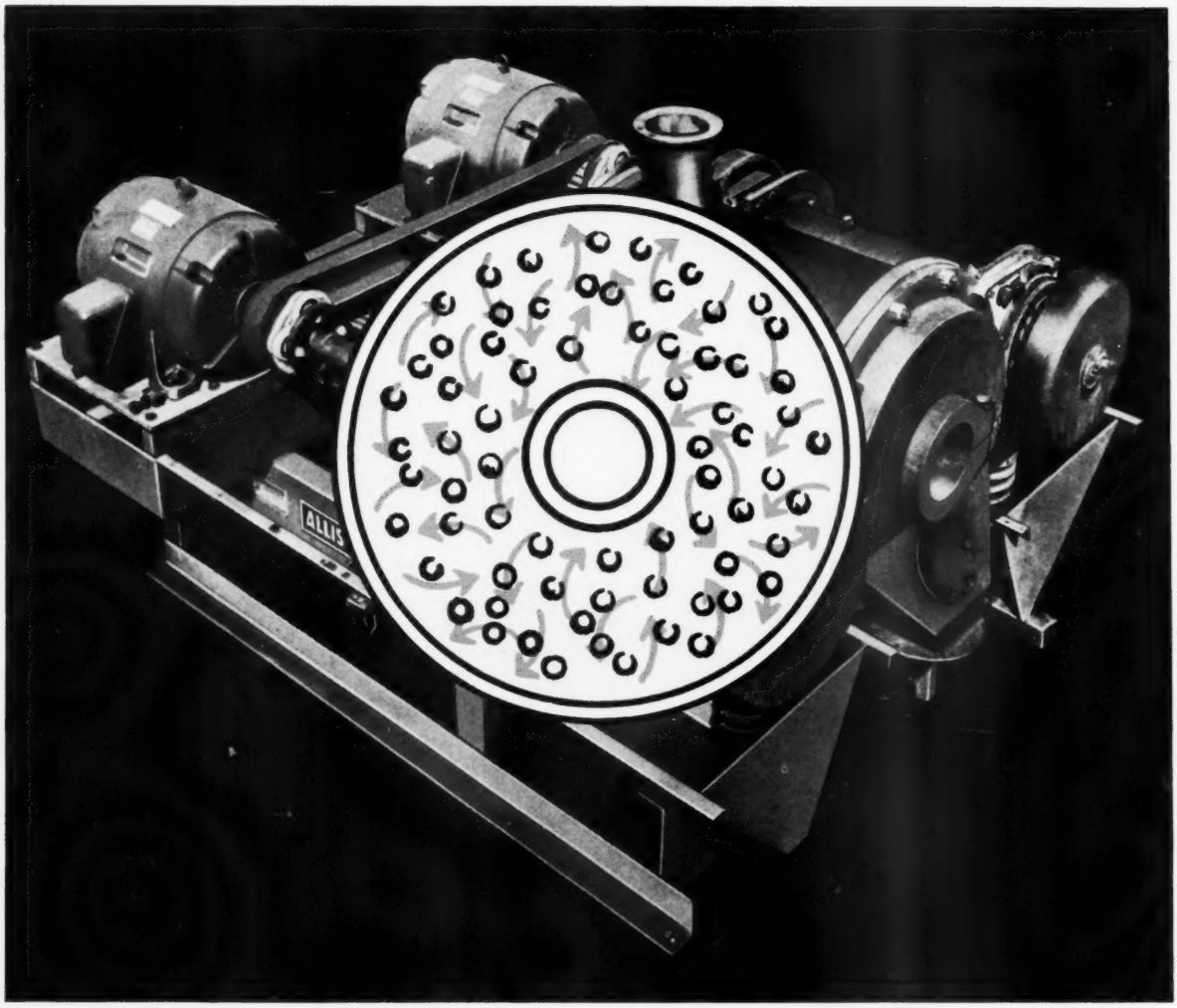
MINING CONGRESS JOURNAL

DECEMBER 1960



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ON OUR COVER

The Staff of Mining Congress Journal extends Greetings of the Season to its readers everywhere



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IN THIS ISSUE—and the

SURVEY OF INDUSTRIAL ENGINEERING IN THE MINING INDUSTRY

Twenty-three industrial engineering departments in the mining industry—14 in the United States and 9 in Canada—supplied information that went into this comprehensive report covering the full scope of I. E. practices in mining. Of the 23 companies surveyed, 20 have established I. E. departments since 1950. The authors summarize and discuss the specific functions being performed and show the extent to which they are practiced. To a large degree, adoption of improvements suggested by I. E. is quickly reflected in the savings achieved. Even where industrial engineering is used, its full potential has not been fully realized.

MAINTENANCE OF MINE POWER SYSTEMS

The four major components of a mine power system using d-c power for face equipment are primary high voltage distribution, a-c to d-c conversion equipment, d-c distribution, and trailing cables. Here is a keen analysis of each component together with suggested maintenance procedures. Full coverage is also given to modern tools of maintenance and system protection. Based on the experience of Bethlehem Mines Corp., the report emphasizes the importance of having adequate power and voltage at machine terminals

MINING HUGE ORE BODIES IN SWEDEN

Kiruna, Malmberget, Gränges berg, and Strássa—four major underground iron mining operations in Sweden—are currently hoisting a combined total of about 21 million tons of ore per year. In order to produce this high tonnage, the operations have been transformed into highly mechanized ones where automation and remote-controlled equipment play key rolls. Techniques and equipment used in drifting, raising, hoisting, blasting and haulage are discussed, as is new equipment which is under development such as automatic and remote controlled drills, trucks and loaders.

BULLDOZERS AS A SUPPLEMENTAL TOOL TO STRIPING SHOVELS AND DRAGLINES

Bulldozer design has now advanced to the point that these machines are being used as the prime production unit at many coal stripping operations. Increased use of hydraulic equipment and attachments, the U-shaped bulldozer blade and the giant sized tractor are some of the major advances that have added to the productivity and usefulness of bulldozers. The author delves into operating costs, production variations according to terrain, and theory of bulldozer use in conjunction with revolving excavators.

(CONTINUED ON PAGE 4)

AUTHORS—

Richard M. Stewart and Stewart W. Hurlbut are director of mining research and senior mining research engineer, respectively, with



R. M. Stewart



S. W. Hurlbut

the Anaconda Co. Stewart was employed by Climax Molybdenum Co. before joining Anaconda in 1943. He entered the research department in 1950 and through progressive promotions rose to director in 1959. Hurlbut joined the company in 1948 and since 1956, he has been working in mining research.

A. E. Molinski joined Bethlehem Mines Corp. in 1938 as a "looper," and has subsequently held positions of electrical repairman, assistant construction engineer, and electrical engineer. Since 1948 he has served as supervisor of maintenance of the company's Johnstown Division.

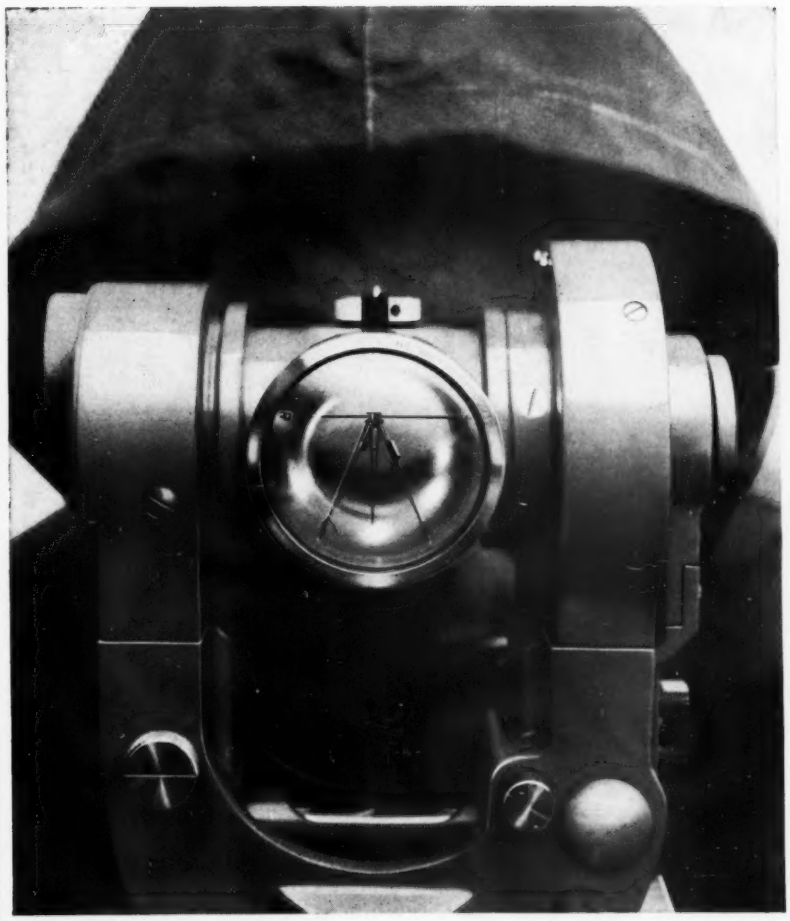


Erik Ingvar Janelid is professor of mining at the Royal Institute of Technology, Stockholm, Sweden. His 20 years in the mining industry include experience in engineering, management, research, and education. Janelid has devoted much of his efforts to underground mining problems, especially those concerned with blasting techniques where his methods and apparatus have found application. He has traveled extensively throughout the world to study mining methods.



C. J. Cooper's early experience was with Caterpillar Tractor Co. in various capacities, such as sales training instructor, track-type tractor specialist in the sales development division, and special earthmoving representative for the mid-Atlantic States. Since 1958 he has been with Beckwith Machinery Co. as earthmoving consultant and has also been associated with the University of Pittsburgh as coordinator of the Open Pit Mining Division, Mining Engineering Department.





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(CONTINUED FROM PAGE 2)

IN THIS ISSUE—and the AUTHORS

HOW A SMALL MINING COMPANY CAN PURSUE MINERAL EXPLORATION

Careful planning, modern equipment and well-qualified personnel are among the necessary ingredients for conducting an effective exploration program today, and, in the writer's experience, a general exploration program requires minimum expenditures of about $75,000 per year. For smaller companies unable to afford this kind of money, a good plan is to form a partnership of up to six parties to provide the finances.

A PRACTICAL LOOK AT PROGRESS IN ROOF CONTROL

"Successful roof control must begin as soon as the coal is removed," according to the author of this up-to-date review of roof control techniques. He considers the trend toward the use of steel in all phases of roof control, the latest roof bolting equipment and techniques, visual tension indicators, roof cementation, steel yielding roof jacks, and many other topics. Of special interest are the roof action studies being made with strain gauges, convergence gauges and sonar devices. Although much progress has been made, the industry is still not able to completely control roof at the present time; hence, it must continue to encourage and participate in efforts and experiments to develop improved methods.

CEMENT RAW MATERIALS—VARIETY IN MINING

A great difference in grade of cement rock, climate, and geography at Permanente Cement Company's four operating quarries creates a wide variety of mining problems. Among these are those concerned with grade control in deposits that range from soft coral to geologically complex limestone. Large stockpiles are invaluable since they permit efficient planning of work and flexibility in the mining operation.

PART II—THE DESIGN OF AMMONIUM NITRATE-FUEL BLASTING AGENTS

The importance of particle size, loading density, admixed oxidizing agents, particle density, and confinement, as factors in the effective use of ammonium nitrate as a blasting agent, has been evaluated by laboratory and field research at the Missouri School of Mines.

Karl J. Springer's notable and colorful career in the Canadian mining industry dates from 1922. He was engaged in prospecting and property examinations for 12 years until 1934, when he formed Karl Springer Exploration Co., the first of numerous mineral ventures. Springer is president of Leitch Gold Mines Ltd., Highland-Bell Ltd., Canada Tungsten Mining Corp. Ltd., and is a director of several mining companies.



Avron V. Gibson's early experience was with United Pocahontas Coal Co. He later accepted a position as assistant mine foreman with Pocahontas Fuel Co. at its Sagamore mine and in 1947 was promoted to general mine foreman. He advanced to superintendent in 1952 and was transferred to the Rolfe mine as superintendent for the same company in 1954. In 1955 he joined New River & Pocahontas Consolidated Coal Co. as division superintendent.



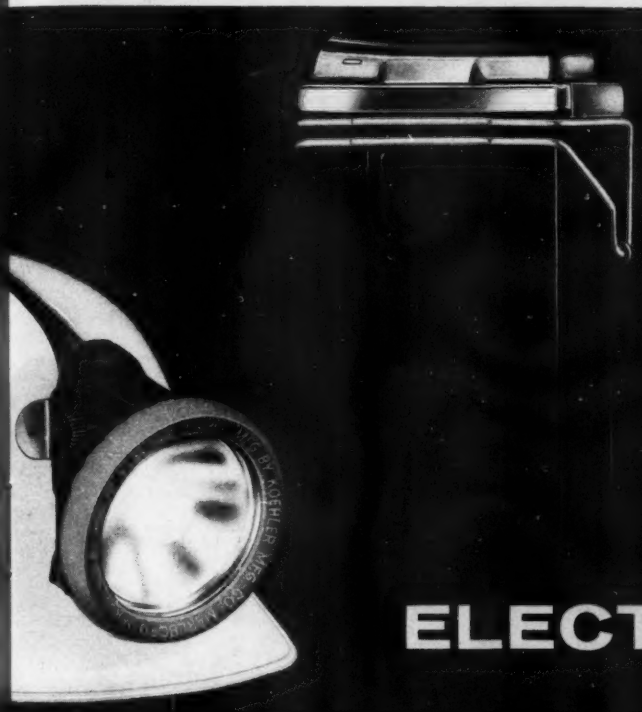
E. B. Conners is mine engineer—planning and development for Permanente Cement Co. He joined Permanente in 1956 at its Cushenbury, Calif., operation as quarry superintendent. Previously, he served for eight years in various engineering and supervisory capacities with Kennecott Copper Corp. at its Ray, Ariz., Mines Division. His experience also includes one year with Combined Metals Reduction Co. and two years with American Metals Co.



Dr. George B. Clark, with the assistance of Robert J. Bruzewski and Dr. Joseph J. Yancik, has presented a keen analysis of ammonium nitrate-fuel blasting agents. Dr. Clark is professor of mining engineering and Bruzewski is associate professor of mining engineering at the Department of Mining Engineering, Missouri School of Mines. Dr. Yancik is research engineer for Monsanto Chemical Co. Prior to joining the University of Missouri in 1954, Dr. Clark had served in various positions at the University of Illinois, U. S. Bureau of Mines, University of Utah, and Tintic Standard Mining Co. of Utah.

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HOW TO MAKE A LOW CAR HIGH IN CAPACITY



To give customers greater load capacity in a shuttle car only 27″ high was one of the problems Joy engineers faced in designing this Model 18SC3 car. They solved it with a unique six-wheeled design using Timken® tapered roller bearings on all wheels. This feature helps maintain all six wheels in contact on uneven ground and enables the car to ride smoother. The design permits 4½-ton capacity and a conveyor 56″ wide, 27 feet long.

Timken bearings are also used on the worm shafts, hydraulic motor and pump shafts, steering axle kingpin and cable reel drive. Their tapered design lets Timken bearings take *both* radial and thrust loads. Their adjustability permits uniform, accurate running clearance, maintains gear alignment and concentricity of seals. Assembly is simplified because the separable components of Timken bearings permit independent assembly of cone on shaft, cup in housing. And the huge range of Timken bearing types and sizes permitted Joy to select exactly the right bearing for each application.



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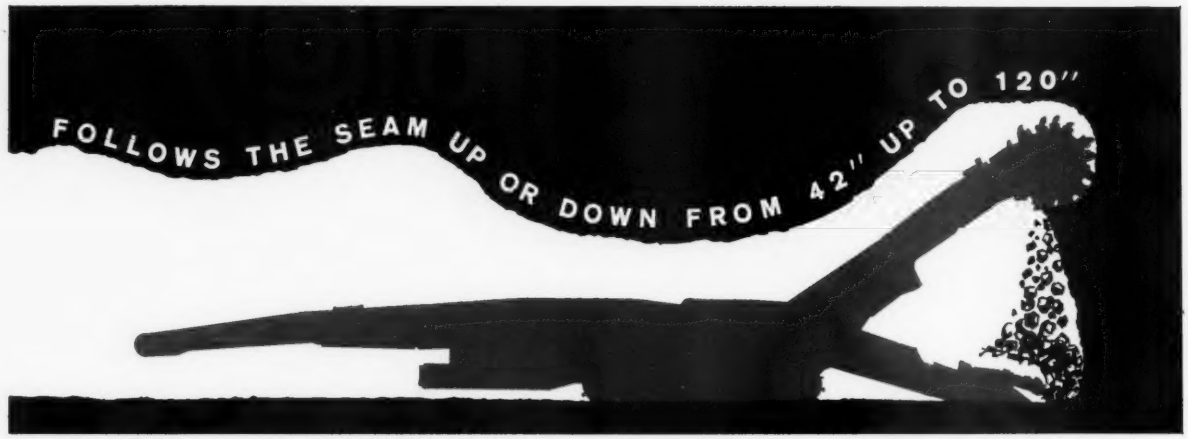
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INSTANTLY CONTROLLABLE CUTTING HEIGHTS

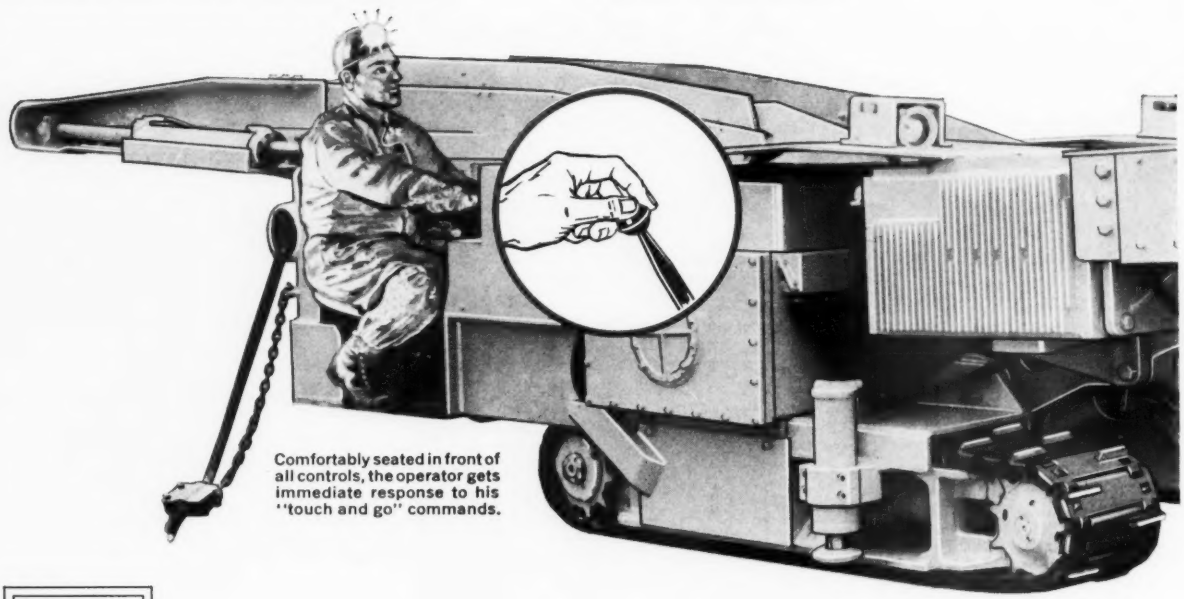
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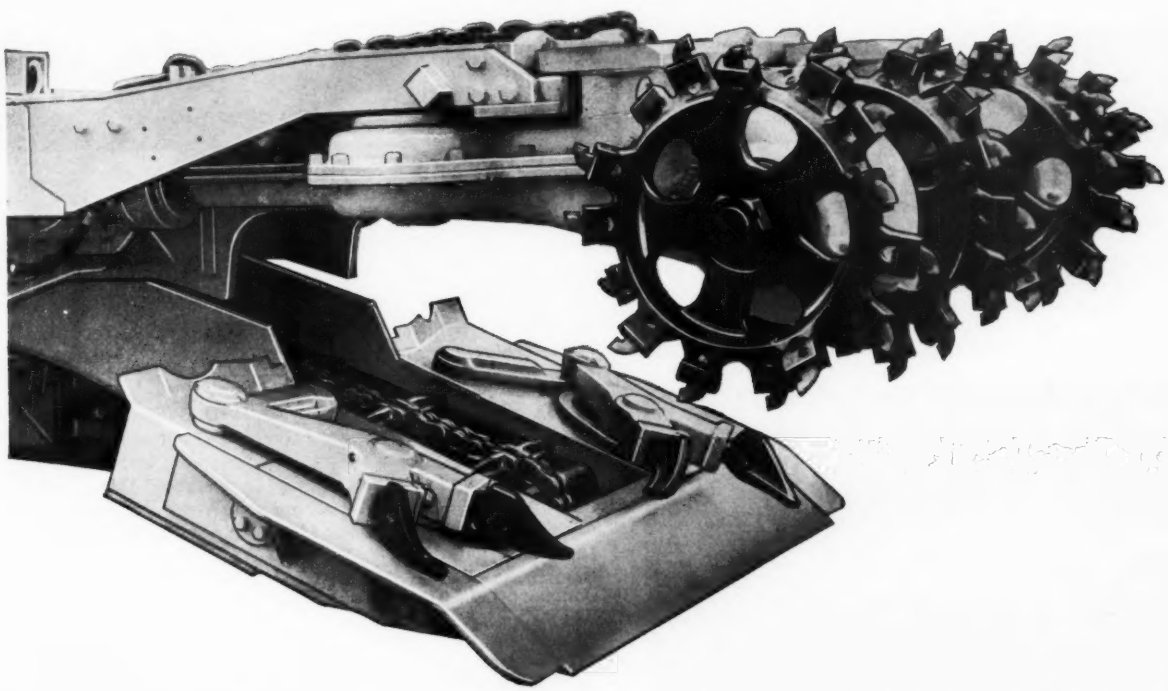
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2. SELECTIVE MINING ABILITY

3. TRAMS LOW—CUTS HIGH

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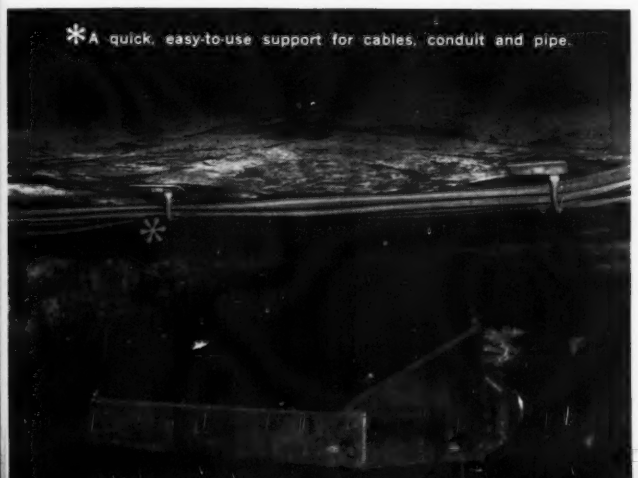
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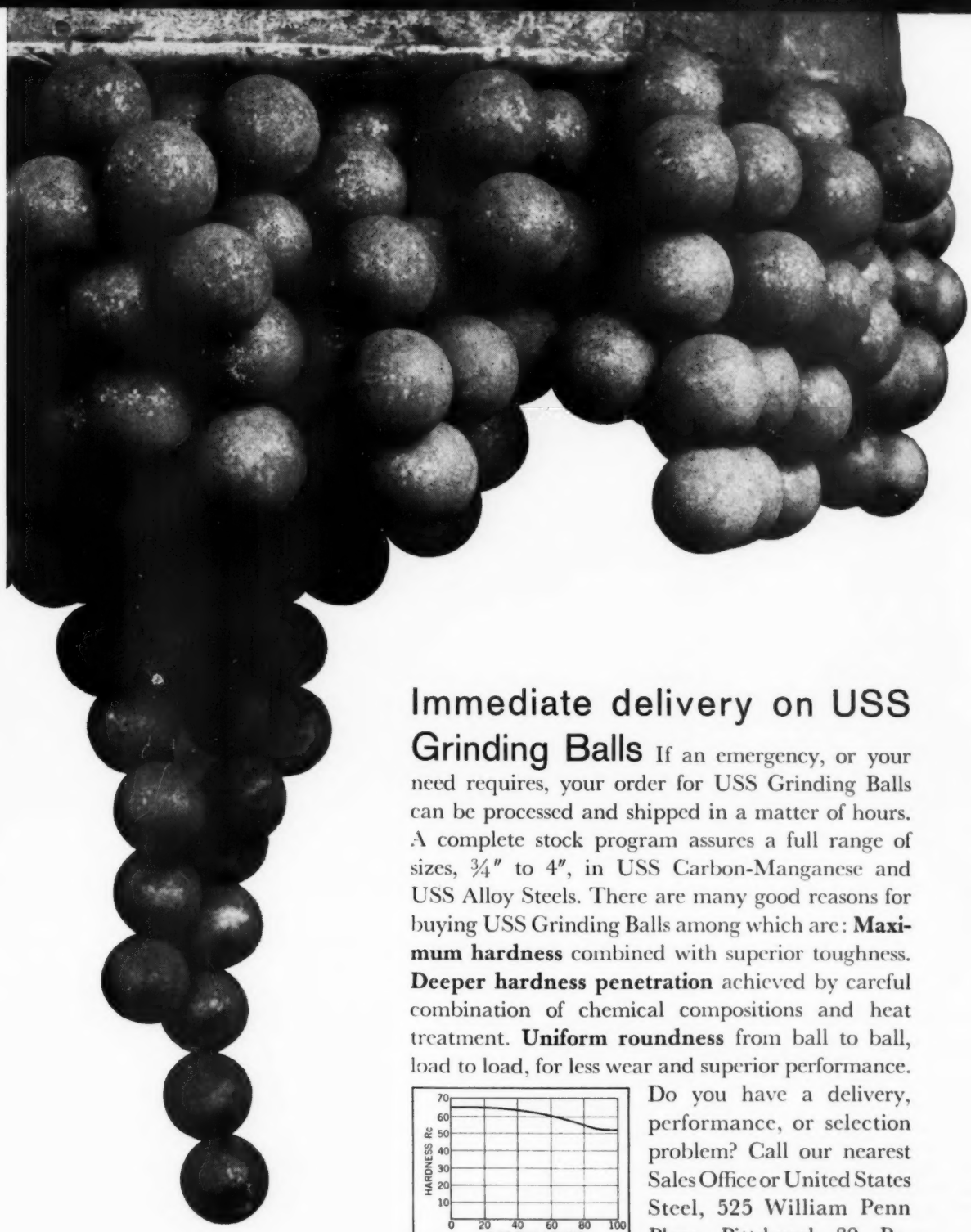
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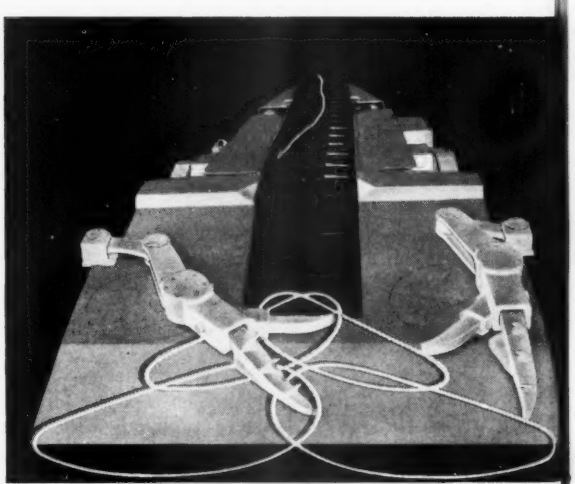
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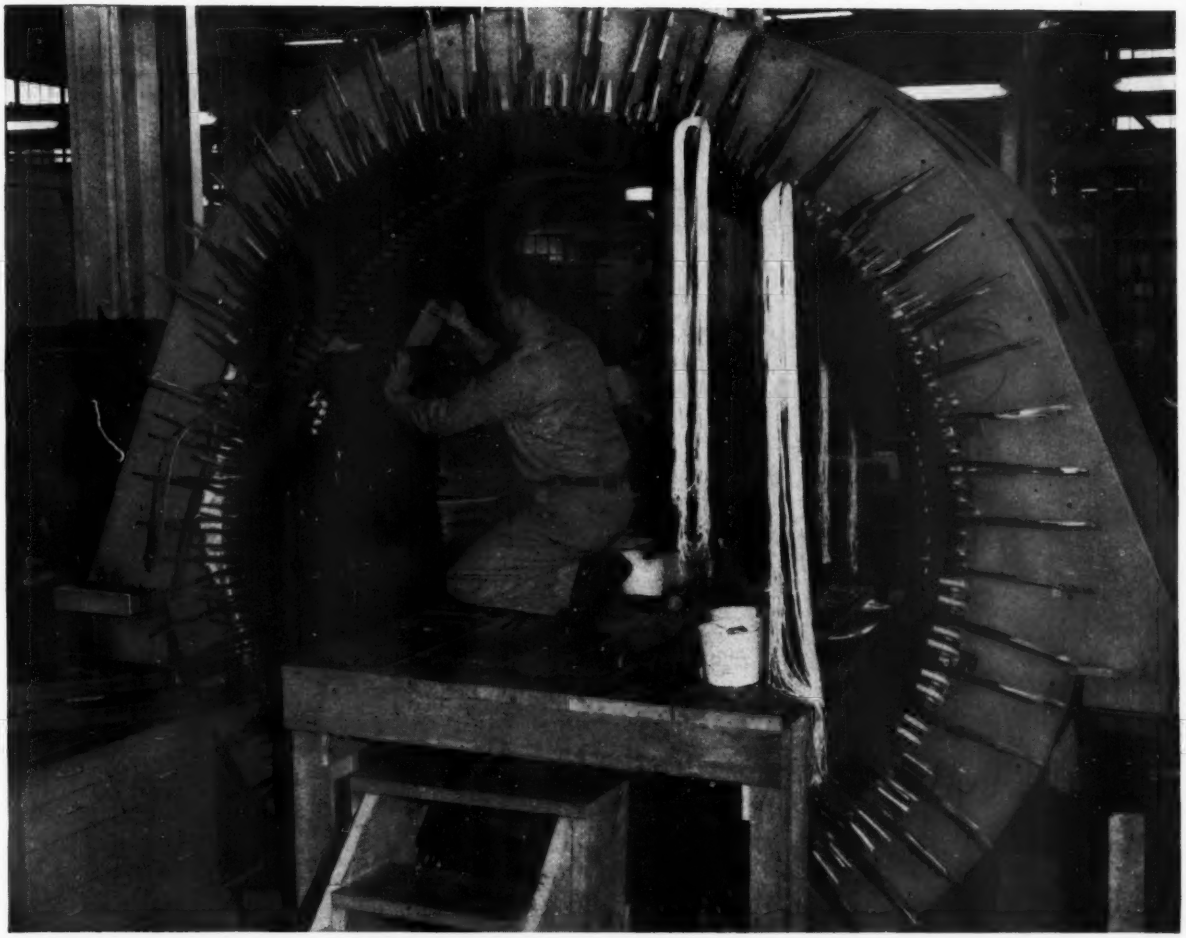
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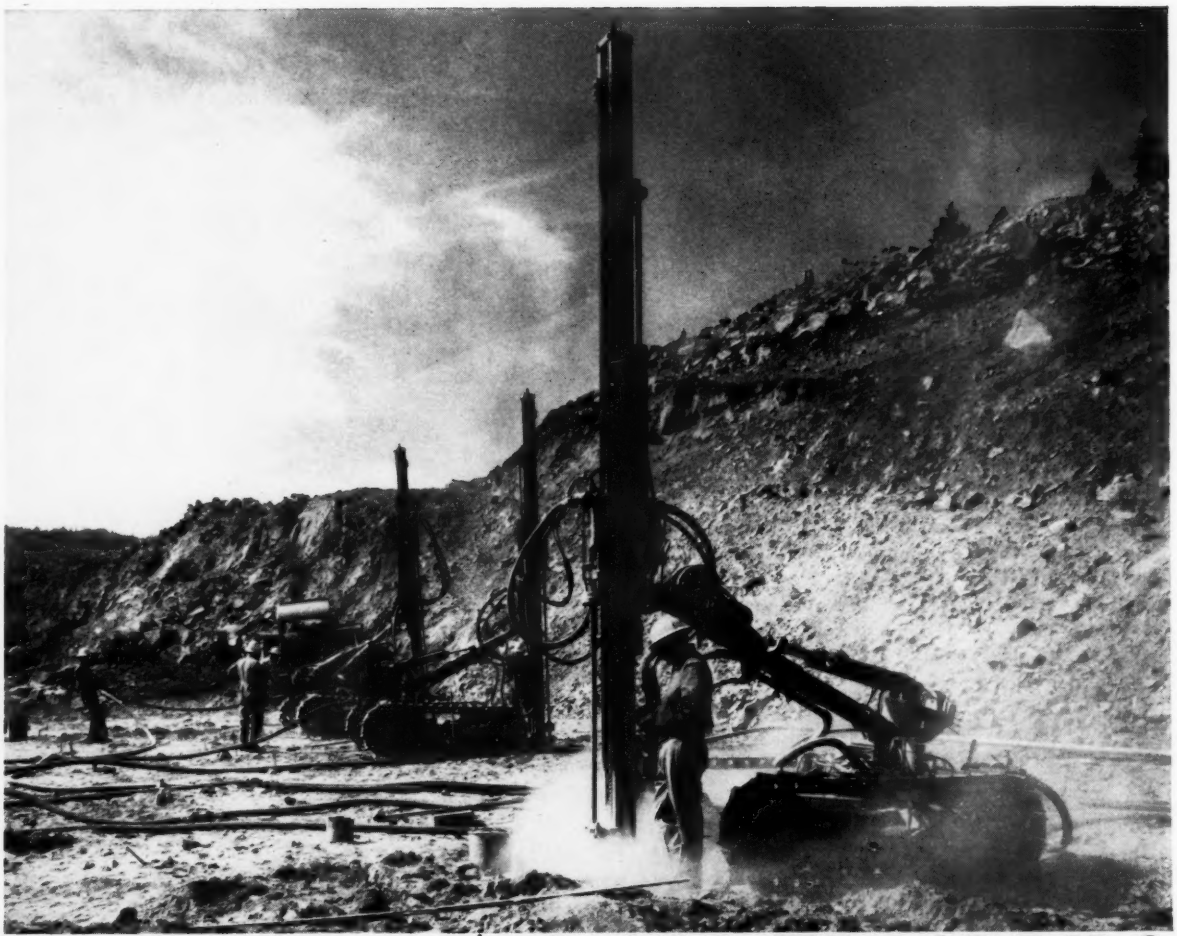
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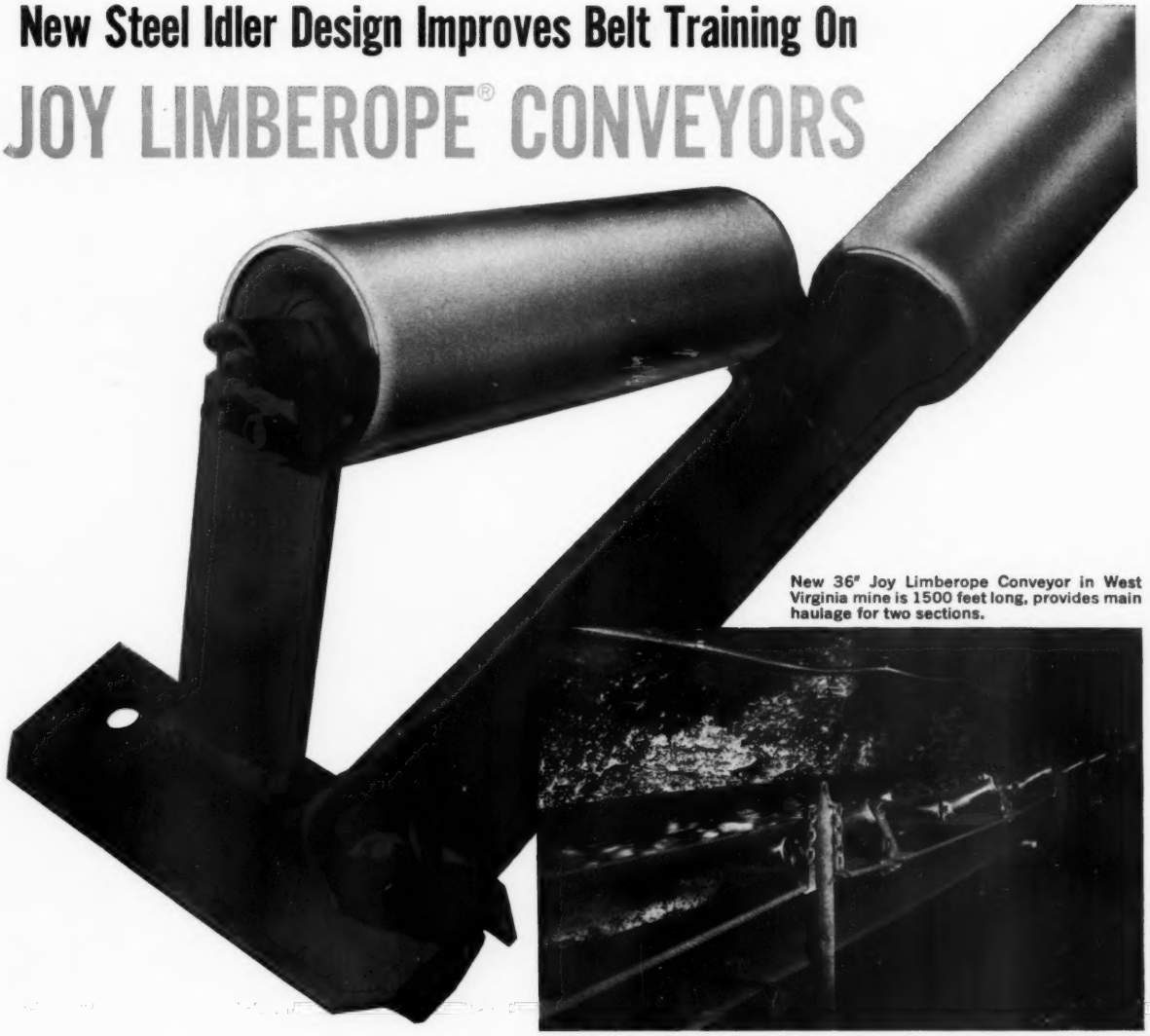
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New Joy Limberope rope belt conveyors maintain excellent belt training almost indefinitely, without attention. Unique new method of clamping the bracket locks it to the rope so tightly that even a blow from a sledge hammer will not move it. Once in alignment, the new Limberope conveyor will maintain alignment against any normal jarring.

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E229-M

This Jeffrey Conveyor

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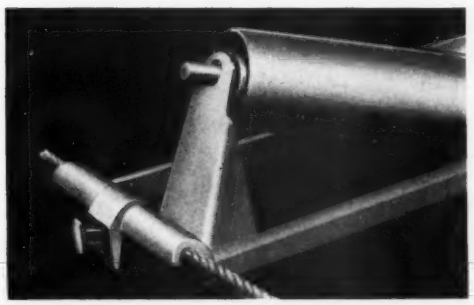
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Belts last longer on these Jeffrey wire rope type conveyors, because of the spring action of the flexible supports as loads pass over troughing idlers. And the Permaseal Idlers are sealed to keep out dirt; prelubricated for years of maintenance-free operation.

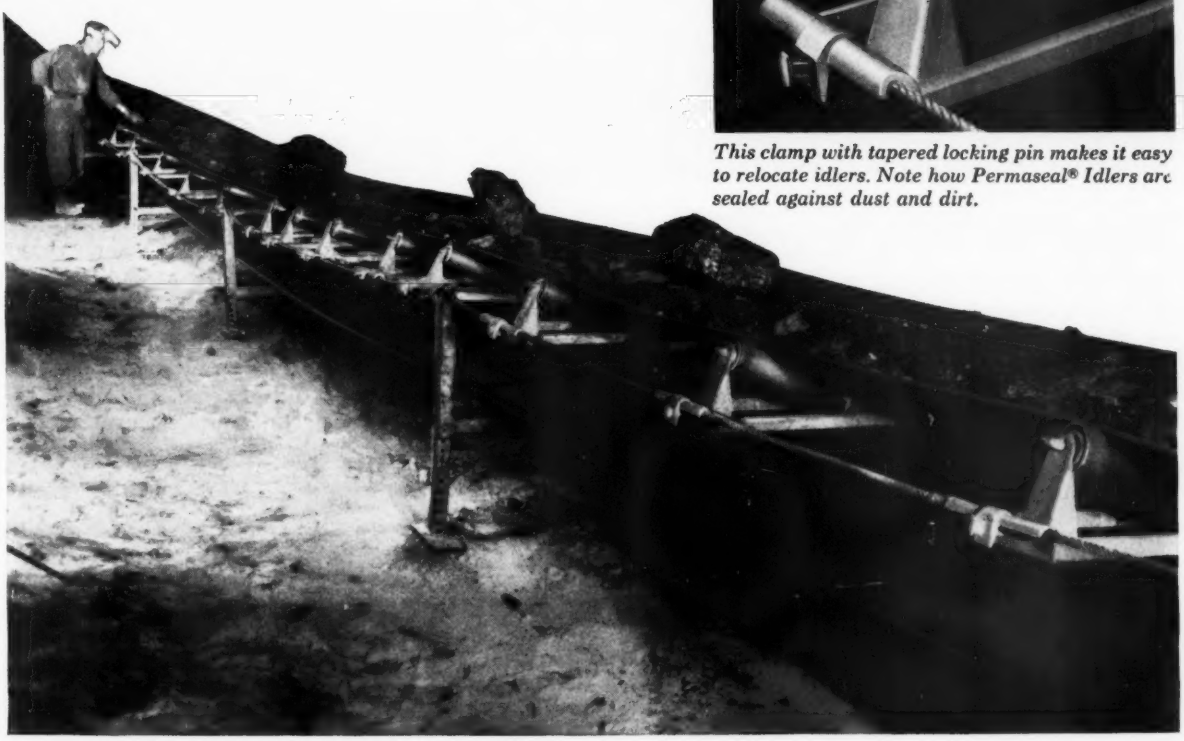
For bulletin containing detailed information on these conveyors, write The Jeffrey Manufacturing Company, 958 North Fourth Street, Columbus 16, Ohio.

JEFFREY

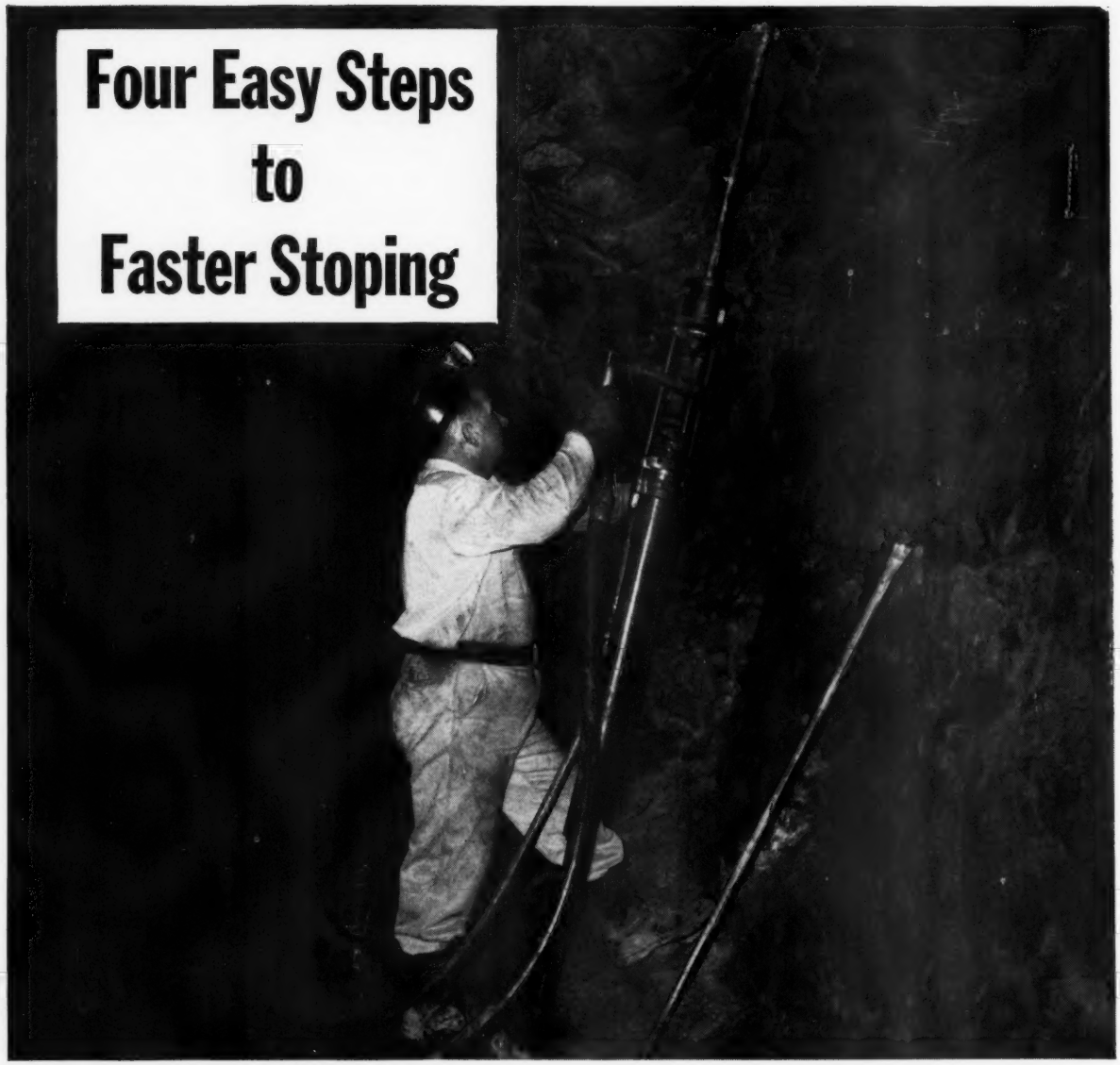
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This clamp with tapered locking pin makes it easy to relocate idlers. Note how Permaseal® Idlers are sealed against dust and dirt.



Four Easy Steps to Faster Stoping



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2. Take your choice of feeds	Direct feed (steel)	X	X	X
	Direct feed (aluminum)	X	X	X
	Telescopic direct (aluminum)	X	X	X
	Reverse feed	—	X	X
3. Specify the chuck to match your steel	Collared chuck	X	X	X
	Tappet chuck	X	X	X
4. Add the type of controls you prefer	Push-button control	X	X	X
	Rotary control	X	X	—
	Stop rotation control	—	X	X

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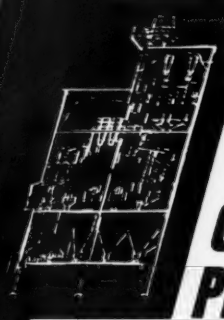
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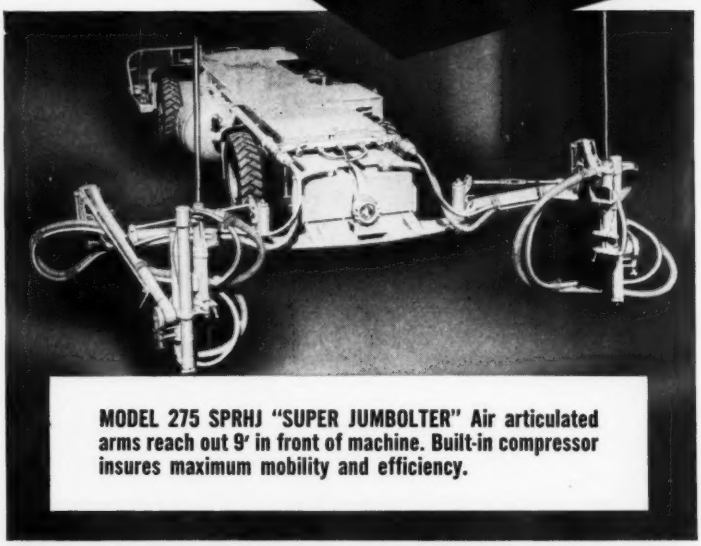
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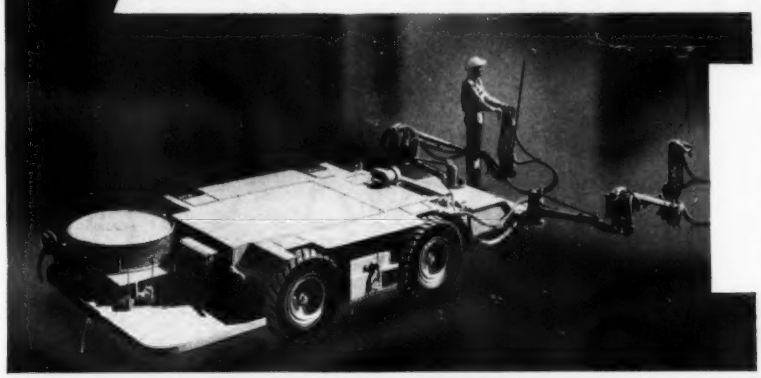
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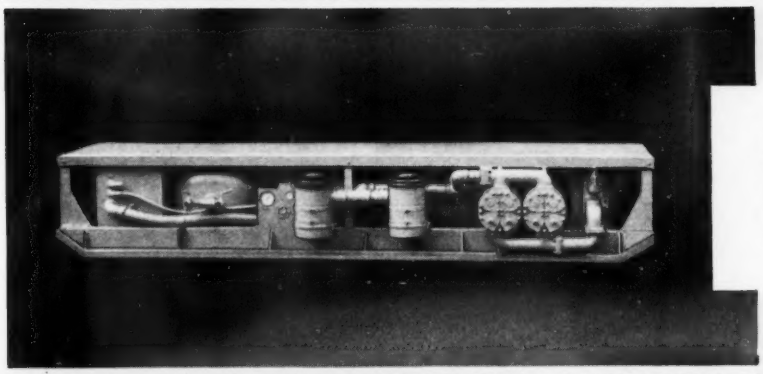
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3 **TIGHTEN THE ASSEMBLY** with an impact wrench to complete the installation. When tightened in the hole the leaves of Bethlehem's Type "C" expansion shell expand in four directions to lock the bolt securely in place.

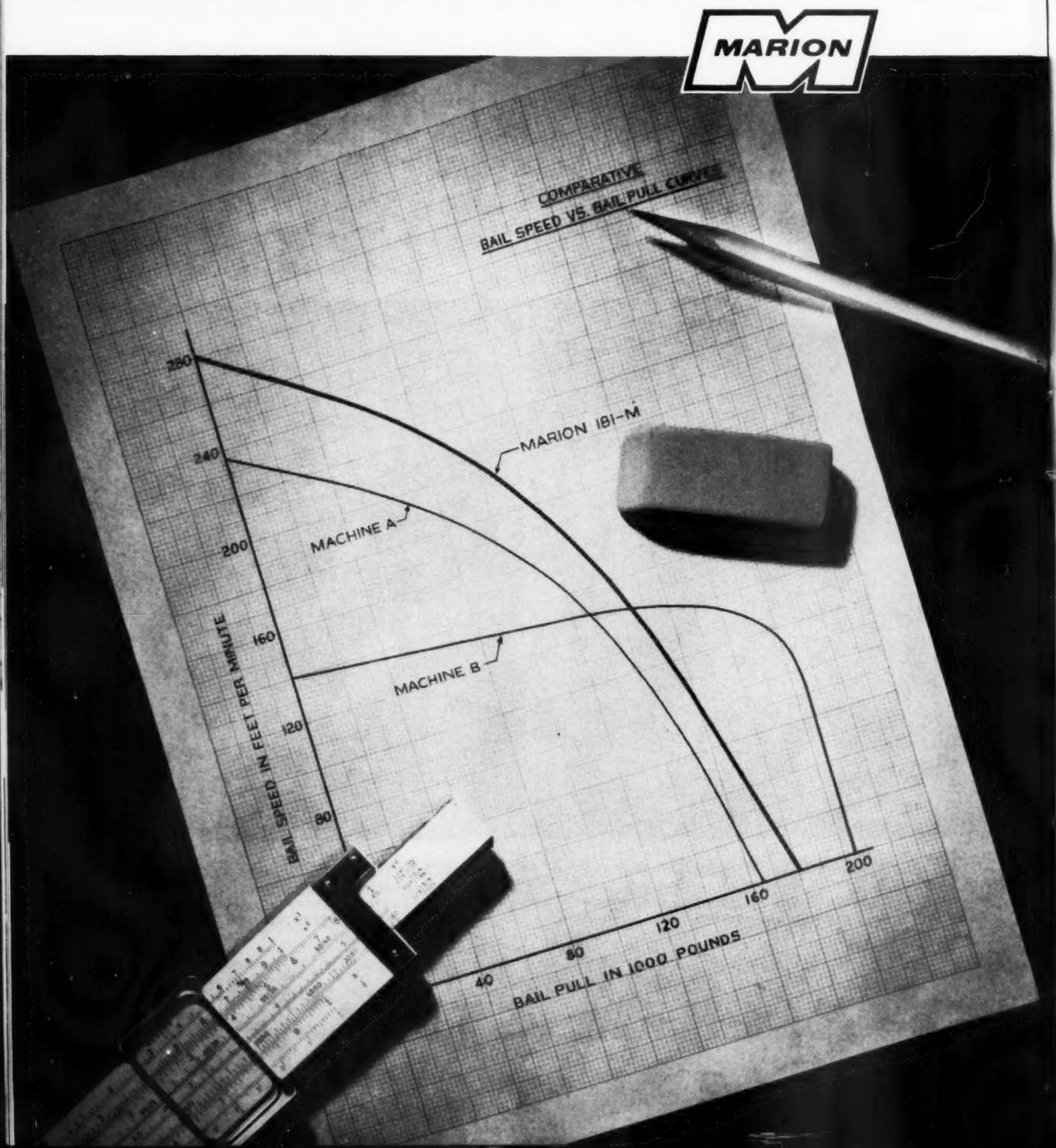
4 **TEST THE INSTALLATION** to assure the accuracy of equipment and bolting crews. Tension testing may be performed at regular intervals. Bethlehem engineers are available to work with your crews on any aspect of the job.

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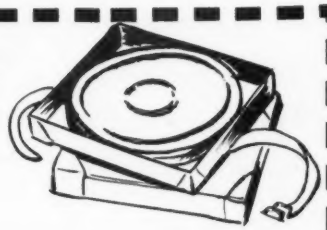


Documentary movie shows how non-stop haulage achieved with fewer men and less equipment.....

A year was necessary to film, at intervals, the operations you will see in this actual case history of a change-over to S-D Automatic Overlapping Cars. It shows operations BEFORE . . . DURING . . . and AFTER conversion to a main line haulage system that reduced cost to the minimum and provided Non-Stop Maximum Haulage — with fewer men and less equipment. It further features Automatic Loading Stations, what they do and how they operate in this mine. This documentary 22-minute color and sound 16mm movie is available now for your review. Ask us to mail this film to you for showing to your operating personnel . . . or, ask us to have one of our representatives bring projector and the movie to show for you. Write or call us today. Use coupon below to make mail request.

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Editorials
MINING CONGRESS JOURNAL
ROBERT W. VAN EVERA, Editor
December 1960

Another Cost-Cutting Tool

One of the lesser known activities of the Atomic Energy Commission is its work in the promotion of peaceful uses of the atom. We all know of the Manhattan project, the A bomb, and now the H bomb; most of us have heard of the dramatic advances in the fight against cancer made possible through the use of radioactivity; but not so many of us are aware of the less dramatic but nevertheless important advances in the use of radioisotopes by industry, as highlighted at the recent AMC Coal Division Conference.

The great variety of radioisotope uses can be divided into three broad classes—tracer atoms for making flow studies, leak detection, and wear measurement; radiation measuring devices to determine the dimensions of an object, density of a medium, and bin or tank levels; and high-intensity radiation which may be used to alter the physical properties of a material, initiate a chemical reaction, or sterilize laboratory equipment. All of these applications are being used beneficially and profitably by industry—the mining industry included.

Much of the advance in this field of technology can be credited to the AEC's Office of Isotopes Development, which administers the Isotopes Development Program inaugurated in 1958. Under this program, AEC is supporting research and development in radioisotope technology, conducting surveys to find where radioisotopes can be effectively used, and expanding the availability of radioisotope training. The result of all this has been to give industry another tool that can be utilized to increase efficiency and cut costs.

National Solidarity

November 8, 1960 has become another significant date in the annals of representative government. Now it is time to adjust our thinking to certain changes in the Federal Government—a Democratic Administration in the Executive Branch, and a reduction of the Democratic majority in Congress.

Whatever may have been the political leanings of our readers—which we know included ardent partisans of both parties—the serious work of Government now demands our elected leaders' utmost efforts to legislate with true wisdom and to administer the laws with impartiality, vigor, integrity and intellectual honesty. To accomplish this, they need the support and help of the electorate, which should be rendered both through individual contacts with Government and through collective groups which have well-defined objectives.

The American Mining Congress, as the national organization of the mining industry, pledges itself wholeheartedly to serving both its members and the Nation by promoting clearer understanding of the industry's problems and helping to formulate sound legislative and administrative policies designed to strengthen the mineral economy of the United States.

Survey of Industrial Engineering

By RICHARD M. STEWART
Director of Mining Research
The Anaconda Company

and

STEWART W. HURLBUT
Senior Research Engineer
The Anaconda Company

INDUSTRIAL engineering is fundamentally a management tool for cutting and controlling costs. Anyone whose job touches on this objective realizes that saying "cut costs" is one thing and doing it another. One of the problems involved is to do it without destroying effective maintenance, a balanced labor force (hourly and salaried), and adequate warehouse stocks. Another is to awaken everyone in the organization—hourly and salaried alike—to the necessity.

Industrial engineering is a well-rounded method of cutting and controlling costs and achieving a smooth-functioning organization at the same time. Paying close attention to human relations, it reaches its goal by making it possible for management to achieve increased utilization of people, supplies, and equipment in every category of operation.

Like any other tool, it has to be sharp and used correctly. The effective use of I. E. to control costs requires:

1. **Complete, firm, and sincere management backing.**
2. **An understanding of the company's operating objectives.**
3. **Staff and line cooperation.**
4. **A detailed cost accounting system with which to work.**
5. **An understanding of human behavior.**

The effectiveness of I. E. is being increasingly recognized by mining management. This article presents the results of a survey of its use in the mining industry.

Breadth of Survey Coverage

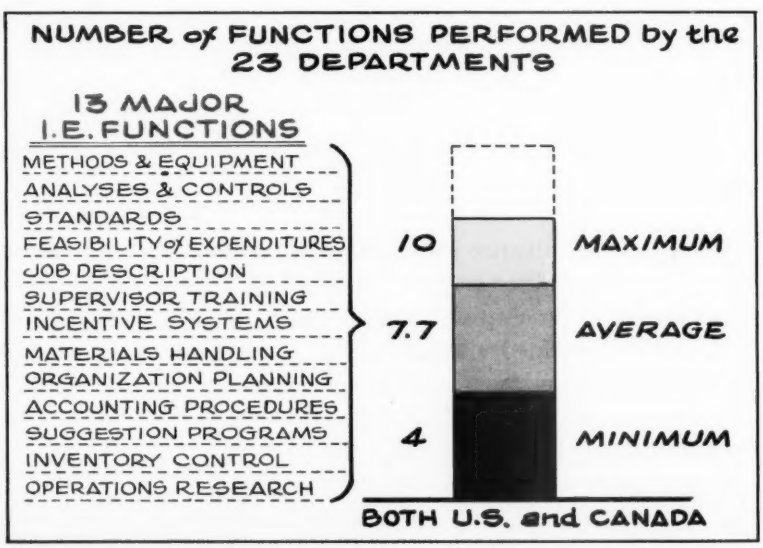
Industrial engineering isn't new; originating as an entity near the beginning of the century, it blossomed slowly but has long since been recognized by most segments of industry as an essential part of the management team. Over 36 colleges and universities in this country offer degrees in the subject, and many others have options as part of other accredited engineering curricula.

The mining industry has been slow to adapt I. E. to its problems, but in the 1950's its use spread rapidly. Of the 23 operations concerned in this survey, 20 of them established I. E. departments during that period.

The use of I. E. in the mining industry, except in coal mining, has not received adequate attention in the technical literature; consequently, a certain amount of detective work had to be done to extend the coverage of this survey as far as possible.

Some of the work now done by I. E.'s has always been done, simply because it was good management practice, but the work was done by different departments. Modern usage concentrates this work in one department and adds tools and techniques not fully utilized previously. Sometimes these departments consist of as few as two or three men who provide I. E. service to the manager.

This survey of 23 departments—14



in the Mining Industry

in the United States and 9 in Canada —of which the writers personally visited 18, covers a substantial proportion of I. E. in North American mining, excluding coal. In Canada, some of these departments are named "work study" or "production engineering."

Types of mines covered are copper, iron, lead-zinc, gold, uranium, molybdenum, potash, phosphate, and asbestos. Open pit, block cave, vein, and open stope mining methods are represented. Coal mining is not included because in many cases its usage is rather well in advance of the rest of the industry and would "salt" the sample.

Mines Included in Survey

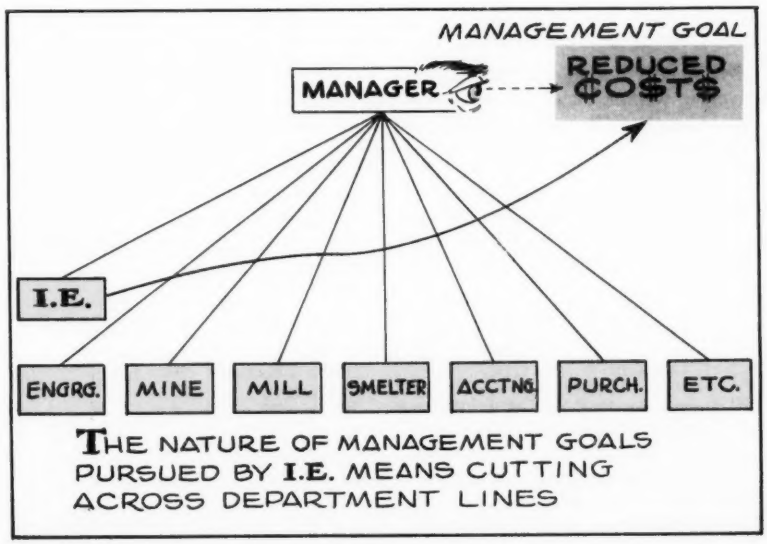
Copper	7	Asbestos	1
Lead-zinc	4	Molybdenum	1
Gold	3	Potash	1
Iron	3	Phosphate	1
Uranium	2	Total	23

Organization of I. E. Departments

Because its functions often overlap those of other departments and because the very nature of I. E. involves investigations wherever costs originate, it is important that the department reports to the top local manager. It was found that in 11 cases the tables of organization show this arrangement. While the remaining 12 report lower down the ladder, it was apparent in many cases that the department maintained close liaison with the local manager.

In many industries, a central I. E. activity at the top management level has been found to have much to recommend it, particularly when it is supported by field activity that is stimulated, encouraged, and coordinated by this group. In the survey, nine departments were found to have representation at top executive level.

At four locations, the departments are clearly subdivided into sections and each assigned to a segment of the operation: mining, concentrating, and smelting. The rest, where the departments are large enough to warrant it, are subdivided by function, that is, by what they do rather than where they work.



THE NATURE OF MANAGEMENT GOALS PURSUED BY I.E. MEANS CUTTING ACROSS DEPARTMENT LINES

It is interesting to note that, in most of the latter departments, work is concentrated on the mining end of operations rather than the metallurgical. In general, this came about because mining costs were higher than treatment costs. It was a question of need rather than applicability.

Functions of I. E. Ever-Changing

What I. E. departments do is presented under a set of function headings arbitrarily chosen. Terminology used in this relatively young and growing branch of engineering is not always rigorously defined and there is unavoidable overlapping. Therefore, broad functions were selected that include most of the activities of the departments surveyed.

It should be emphasized that most of the departments are in a state of transition. Functions are changing and will continue to change as the departments mature within the organization and as developments occur in industrial engineering technology.

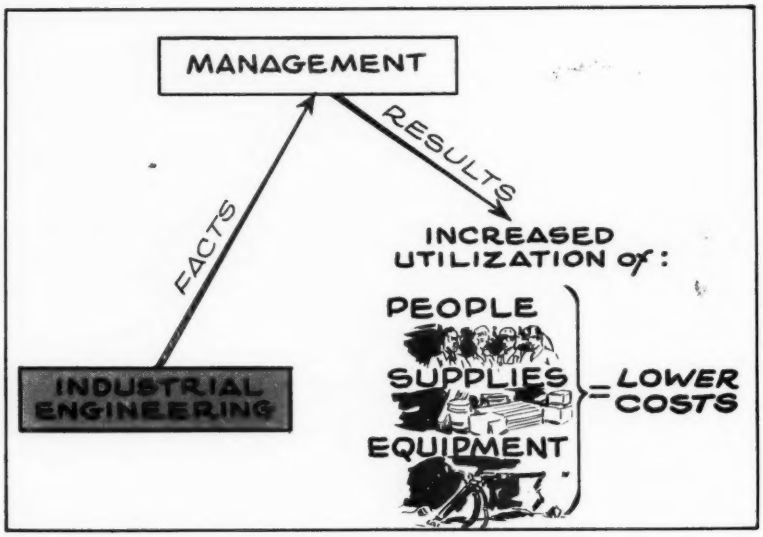
The functions will be discussed for the most part in descending order of percentage of the 23 departments surveyed that are performing them. The percentages are not weighted for the amount of time spent by the various departments on particular functions. It was found exceedingly difficult, for instance, to differentiate between amount of time spent on methods and equipment and time spent on standards.

Methods and Equipment Studies

Both	100%
U. S.	100%
Canadian	100%

Method study—determining the safest and most economical way to do work—and equipment study—determining the best tools and equipment used to do work—go hand in hand. In most cases, they are also vital in establishing standards.

It was found that all departments spend some of their time on methods and equipment, especially before establishing standards. However, in some cases in Canada, due to the urgent need to overhaul the incentive systems, standards have been established on current practice with the intent to later standardize and improve methods and equipment and then modify the performance standards. But in most cases, industrial engineers time study the operation, highlight areas where improvements can be made, work with the operators to implement the improvements, and then set standards.



Cost and Production Analysis and Controls

Both	91%
U. S.	93%
Canadian	89%

Since, by definition, I. E. is a management tool to cut and control costs, it is natural that most departments are involved in the mechanisms of control. Thus, 91 percent establish and maintain analyses and controls. It is in this area of activity that cooperation with accounting is of great importance.

Establish and Maintain Standards

Both	83%
U. S.	73%
Canadian	100%

What particular functions are practiced usually develops by necessity. That is, the various mining companies adopted I. E. for specific and usually urgent purposes. All Canadian departments work intimately with incentive systems. This has required establishing standards for a fair day's work and these are the basis for equitable incentive systems. The trend in Canada is to put incentives on more and more underground work such as tramming, skip-tending, and even maintenance.

Help Administer Individual Incentive Systems

Both	43%
U. S.	7%
Canadian	100%

In the United States, standards are established for a slightly different purpose, since help in administering individual incentive systems is a function at only one of the properties (although some type of incentive system is used at six others). Here emphasis is placed on establishing standards for the supervisor. It takes the description of a fair day's work out of the realm of opinion, and gives the supervisor a real tool with which to up-grade the production of his men.

Feasibility of Capital Expenditures

Both	74%
U. S.	79%
Canadian	67%

Reporting on the feasibility of capital expenditures falls within the province of I. E. at 74 percent of the properties. The objectivity of an I. E. report is stressed in management decisions to buy new capital equipment or to engage in expansion.

Job Description and Evaluation

Both	70%
U. S.	57%
Canadian	89%

Ordinarily, setting standards involves a written description of the job, but not necessarily so. And describing a job does not necessarily mean that the process is carried the logical step further to evaluation. In United States usage, some operations have job evaluation programs while others pointedly avoid them.

Supervisor Training Programs

Both	65%
U. S.	64%
Canadian	67%

Management backing of I. E. assures at least an audience in the lower echelon of companies. The survey revealed, that in all cases, the lowest degree of acceptance is found in the ranks of first and second line supervisors. Accordingly, 65 percent of the departments have active programs of training supervisors in one or more phases of I. E. Where incentive systems are in use, it is believed of particular importance that the supervisors have a thorough understanding of what standards are and how they are established.

Training is given on both the company's and the supervisor's time. Tests or quizzes may or may not be administered, although they are frequently used to determine whether the message is getting across. The amount of training varies from a few days of classes to taking the supervisors into the department for periods of from two weeks to a year or more.

Plant Layout and Materials Handling

Both	39%
U. S.	50%
Canadian	22%

Although plant layout and materials handling is performed largely by the respective plant engineering departments, it is inevitable that in many studies industrial engineers are concerned with this function.

Organization Planning

Both	39%
U. S.	57%
Canadian	11%

To I. E., as a management tool, often falls the task of studying the organizational structure in order that management can streamline and strengthen it. Thirty-nine percent perform this function.

Accounting Procedures

Both	39%
U. S.	57%
Canadian	11%

Industrial engineering depends heavily upon detailed cost reporting in its studies. Therefore, 39 percent of the departments work with accounting to ensure the type of cost presentation best suited to the operation. Frequently this extends to helping set up a budgetary cost control program. Once adequate cost reporting is established, this function is usually dropped.

Suggestion Programs

Both	35%
U. S.	50%
Canadian	11%

Work with employe suggestion programs is performed at 35 percent of the properties. The departments take part to varying degrees ranging from occasional appraisals to administering the entire program.

Work simplification or method improvement training programs are in force at four properties, at least, but these are confined to salaried personnel and usually do not involve monetary rewards. They have proved to be excellent media for teaching I. E. techniques and ways of thought to supervisors.

Inventory Control

Both	30%
U. S.	36%
Canadian	22%

Thirty percent of the departments include inventory control as a subject of at least occasional surveillance. With the trend in industry to closer control of inventories through punch card systems or by use of computers, it appears logical that the mining industry will utilize I. E. increasingly in the future to help establish inventory control inasmuch as substantial savings are frequently possible.

Operations Research

Both	9%
U. S.	14%
Canadian	0%

Operations research, the solution of management problems by using the whole system approach (our definition) is applied in appreciable degree at only 9 percent of the properties. It is understandable that the other approaches of I. E. have been stressed in the mining industry, but, nonetheless, the field of applicability of operations research in both mining and metallurgy is large.

We have seen the distribution of functions performed by the various departments and that methods and equipment studies, cost and production analyses and controls, and establishing standards are the three functions performed most widely.

Now let us look at the distribution of functions in a different way. It is evident that I. E. embraces a potentially wide field of investigative activity, but no department in mining was found that practices as much of the full potential scope as do many in manufacturing industry. Of the 13 functions listed, the average number performed was 7.7 or 59 percent.

Percentage of Functions Performed

	Avg.	*Range*
Both	59%	31% to 77%
U. S.	61%	31% to 77%
Canadian	57%	38% to 77%

Diversity of Personnel in I. E.

The diversification of activities involved in I. E. produces a commensurate demand on personnel. How is the mining industry handling this problem, both as to quantity and type of personnel?

Personnel From Within Company

Both	75%
U. S.	72%
Canadian	78%

To obtain the advantage in training men already familiar with company operations, both U. S. and Canadian departments secure on the average 75 percent of their non-clerical personnel from within. This policy, however, overlooks the potential gain of getting into the company men from outside sufficiently trained in I. E. techniques to up-grade the department's over-all effectiveness.

Number of Graduates*

Both	50%
U. S.	82%
Canadian	20%

** In percentage of total graduates and technicians.*

Graduates with I. E. Degree**

Both	21%
U. S.	30%
Canadian	4%

*** In percentage of total graduates, 17 departments reporting.*

There is a marked difference between U. S. and Canadian usage in regard to the number of college graduates used to staff the departments, 82 percent being graduates in the U. S. and 20 percent in Canada. Of the graduates, 30 percent have I. E. degrees in the U. S. and 4 percent in Canada.

In Canada, a sufficient number of graduates with I. E. degrees to fill the need simply aren't available. This is also the case in the U. S. but perhaps to a lesser extent. Despite the increasing number of colleges offering I. E. degrees, the demand from industry is so insatiable that it is only by persistent search that a few can be enticed into mining, where work conditions are often less desirable than in manufacturing. Some departments in the States have found it necessary to pay moving expenses in order to compete. In addition, in well-established departments, salaries frequently range higher than comparable jobs in other staff departments.

Number of Clerical Personnel

Both	12%
U. S.	13%
Canadian	9%

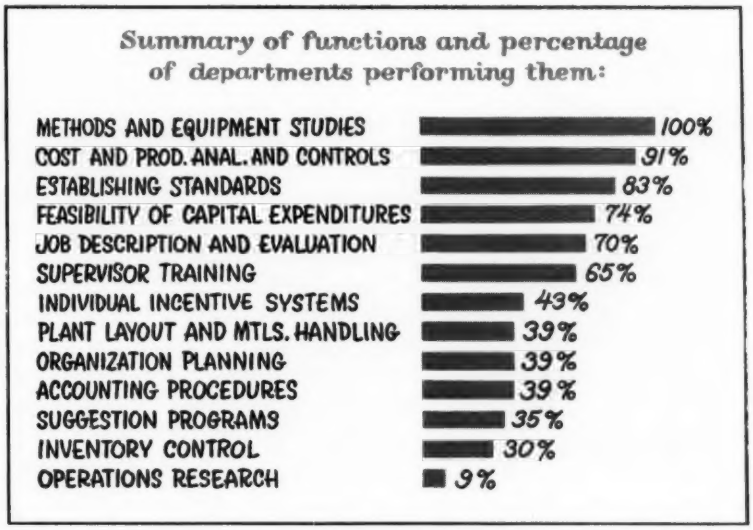
Twelve percent of the departments surveyed consist of clerical personnel.

Number of People in I. E. Departments Per 100 Total Employes

	Avg.	*Range*
Both	0.75	0.26 to 1.96
U. S.	0.71	0.33 to 1.17
Canadian	0.80	0.26 to 1.96

The average number of people in I. E. departments per 100 total employes is 0.75. This is considerably lower than in the manufacturing industry, where the average is over 1 per 100.

Training—Training of personnel is usually a continuous problem, particularly in those companies that have established a policy of funneling men through I. E. into supervisory positions as 57 percent of them do. New mining engineers, etc., have to be taught I. E. techniques; new industrial engineers have to be taught mining. Larger departments find them-





selves taking on men with a variety of educational backgrounds to give them versatility. One such has men with degrees in mining, industrial engineering, chemistry, mathematics, metallurgy, accounting, business administration, education, mechanical engineering, and physics.

Success Depends on Management Backing

In 16 cases, the I. E. departments were established by the top executive branch of the company; in five, by the local management; and in two, by the equivalent of mine superintendents. Wherever I. E. is utilized or discussed, it is accepted as axiomatic that the first requirement for a successful program is management backing. It was apparent during the survey that there are degrees of management backing ranging from Gibralter-firm to lukewarm. Needless to say, the success of the I. E. efforts in the case of the latter was also lukewarm. In the words of one of the Canadian industrial engineers, "Without good management backing, you're dead!"

Line Supervisors—Production personnel must be thoroughly sold on I. E. Their cooperation in making effective studies is imperative and perhaps even more so in the implementation of improvements resulting from such studies. Cooperation is a two-way street. The cooperation of the line supervisor has to be matched with an understanding and non-obtrusive attitude on the part of the industrial engineer making the study.

Understanding of what I. E. is and what management objectives it is working toward is of utmost importance to the line supervisor. This is reflected in the efforts of many progressive mine managers to make all of their supervisors I. E.-minded by emphasizing training programs and by funneling I. E.'s into supervisory positions.

Other Staff Departments—Introduction of I. E. into a company is frequently viewed with suspicion on the part of other staff personnel. The very nature of the management goals pursued means cutting across department lines. The chief industrial engineer finds that much of his work is of a diplomatic nature, smoothing ruffled feathers by pointing out that special studies in another's field are not designed to usurp the functions of the other.

Understanding on the part of other staff department personnel can generally be achieved by teaching them, as well as line personnel, the goals and techniques of I. E. The prime point to get across is that industrial engineers are set up to make special, objective studies that management requires as a basis for decisions.

Use of Consultants

Operations That Have Used Management Consultants In Connection With Industrial Engineering Programs

Both	70%
U. S.	50%
Canadian	100%

It is understandable that, in the broad field covered by I. E., there is a large amount of specialized knowledge to be imparted to department personnel who have not had the benefit of formal I. E. education. For this and other purposes, consultants have been used by 70 percent of the operations.

In some instances in the United States, trained industrial engineers have been hired and thrown together with engineers from within the company for the purpose of mutual education. This has worked out well, but due to the scarcity of these professionals, other companies have found it expedient to get expert guidance from consultants.

In general, Canadian practice has been to hire consultants for relatively long periods of time—from a few months to several years—for initial guidance where a department is being newly established. For review purposes or for special cases, consultants are used for shorter periods. United States practice is characterized by relatively short period use of consultants, from a few days to several weeks, to advise management and to guide the department.

Purposes For Which Consultants Have Been Used

1. Explain to management what I. E. can do for the operation.
2. Help set up the program by pointing out where large savings can be made in the shortest time — "skimming the cream."
3. Train staff in I. E. techniques.
4. Review department's work.
5. Assist on special projects:
   a. Warehousing.
   b. Policy manuals and salary evaluation.
   c. Accounting procedures.
   d. Method improvement training programs
   e. Maintenance programs.

What is to be Gained?

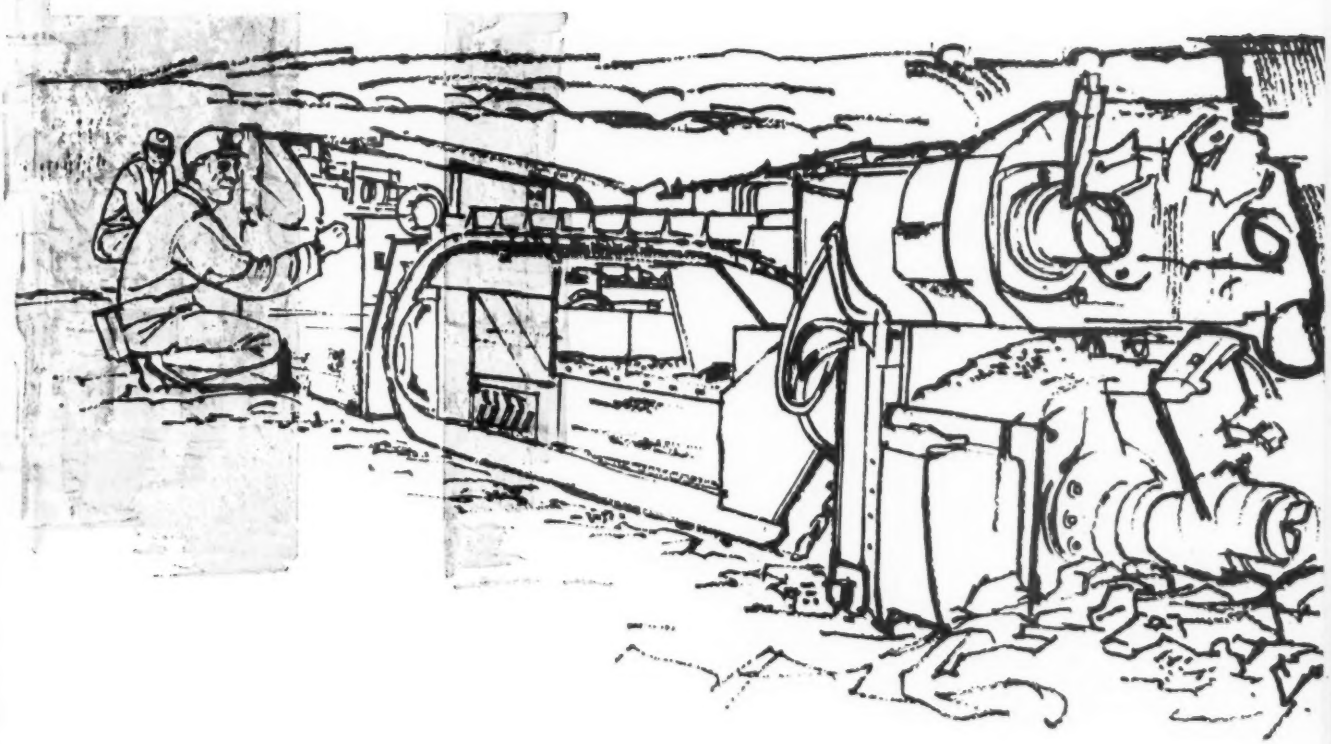
Although there are also intangible benefits, an evaluation of the use of I. E. in the mining industry must rest principally on dollars returned. An investment here is evidently like casting bread on the water. Where ratios of return have been calculated, for every dollar invested there has been a return of from four to five dollars, and there are instances of much higher returns.

The direct savings achieved through the use of I. E. naturally depends upon implementation of improvements by operators and by other staff department supervisors. But, other things being equal, the savings are quite likely not to occur unless I. E. is there to point the way and plan engineered cost reductions.

It is noteworthy that application of I. E. is occasionally a matter of last resort. At least three operations consulted would not be active today had it not been for the controlling of costs achieved through crash I. E. pro-

(Continued on page 38)

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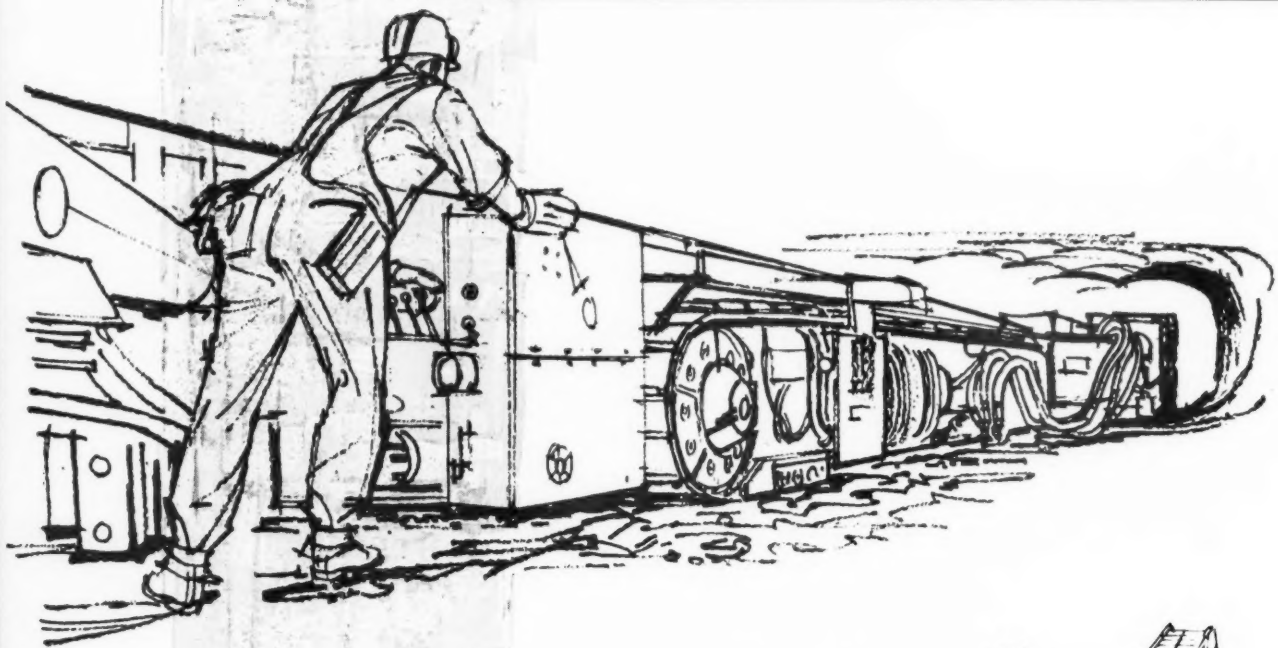
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Maximum mining height	44″	60″	77″	96″
Minimum mining height	28″	38″	50½″	67″
Width of cut	14′-7″	9′-8″	10′-9¾″	10′-9¾″
Minimum tramming height	25¼″	34½″	48¾″	63¾″
Width over crawlers	10′-0½″	72″	77″	77″
Length	34′-3″	29′-5½″	33′-10″	33′-10″
Tramming speed (feet per min.)	22′	20′	20′	20′
Feed speed (inches per min.)	0″ to 51″	0″ to 36″	0″ to 36″	0″ to 36″
Electric motors (total HP)	190	150	190	250
Weight—approx. (lbs.)	92,000	56,000	73,000	75,000

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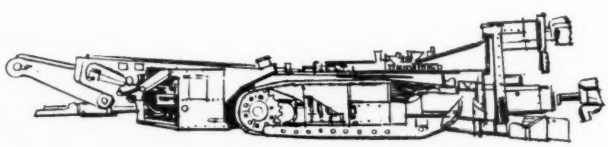


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86-A 76-AM 76-BM 76-CM

2 CONTROL — Colmol mining is controlled mining. The operator is in full command, gets smooth, immediate, positive response from electric-hydraulic controls . . . centralized for convenience, safety, easy access . . . located so that the operator has an unobstructed view of cutting and discharge operations . . . minimum operator fatigue.



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By A. E. MOLINSKI
Supervisor of Maintenance
Johnstown Division,
Bethlehem Mines Corp.

Maintenance of Mine Power Systems

An electrical engineer who has been with Bethlehem Mines Corp. since 1938 describes his company's approach to the problem of proper maintenance of underground d-c power systems

DURING the last 15 years, the greater use of highly specialized high-horsepower mining machines in the coal industry has created a greater need for adequate power and voltage at machine terminals. As mechanization spread, the men responsible for the care and maintenance of mine power systems developed detailed procedures to keep equipment running at peak efficiency. The procedures outlined here are a compilation of proper maintenance practices employed at various facilities of Bethlenem Mines Corp.

To emphasize the great need for proper maintenance of a power system, let's go back a few years. In the days of "hand loading," very little attention was paid to the electrical system; voltage drop was not considered very important to over-all efficiency. Most face equipment was rated at 210 volts and the service voltage seldom dropped below this value.

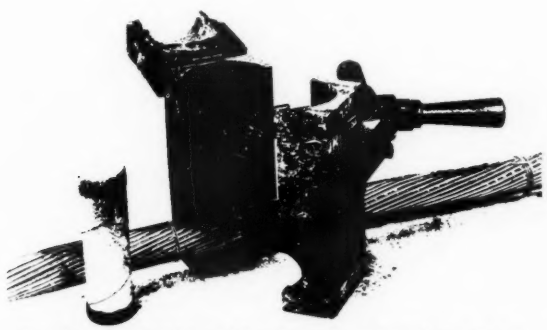
Today's equipment, however, requires full rated voltage at the motor terminals; otherwise, production will suffer. D-c motors, for example, tend to slow down almost in direct proportion to voltage drop. When motors run slower than normal, the machines powered by these motors become sluggish and slow-acting. Frequent cable and armature failures occur. And the operator becomes impatient and treats his machine carelessly. Under these operating conditions, production falls off drastically.

Reduced voltage also causes cables or motor conductors to be subjected to high current overloads. Result: the resistance of the copper conductors increases and the cable voltage drop increases. Thus, the voltage to the machine is further reduced and more heat is produced. The condition keeps getting worse—and could possibly end with cable or motor failure.

Here's a typical example of the effect of reduced voltage. Consider a 50-hp d-c motor with 85 percent efficiency, served by a 1/0 cable 300 ft long, and handling the same work at 270 volts and at 180 volts. The extra power loss in the conductors at 180 volts compared to that at 270 volts is about two kw. Thus, the extra heat generated in one hour is equal to the heat equivalent of 30 lb of coal.

Components of Mine Power System

The four major components of a mine power system using d-c power for face equipment are primary high voltage distribution, a-c to d-c conversion equipment, d-c feeder distribution and trailing cable. Let's analyze each component separately and then outline suggested maintenance procedures.





Figs. 1 and 2. Bethlehem Mines' experience has shown that a Thermit weld joint is more efficient and less costly to install than solder or clamp connections. Various types of lugs or terminals are available for this type of welding. The above views show (left) two 1000 MCM cables positioned for welding and (right) a cable positioned with lug (⅜ by 1½-in. copper bar) for welding

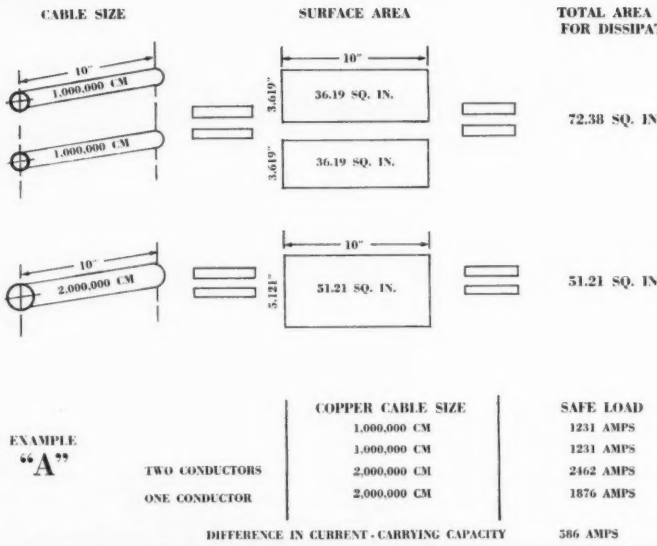


Fig. 3. Two lengths of 1,000,000 CM cable have the same cross section as a single length of 2,000,000 CM cable. But, as shown in the sketch, the two lengths of smaller cable have a total surface area that is over 40 percent greater than the single length of large cable. Thus, the two smaller cables would be more efficient in dissipating heat and therefore could carry more current than the single large cable

Primary high voltage distribution. This system will differ considerably at each coal mine; each system should be studied individually. However, maintenance problems on these systems generally are not serious. Thus, there is no need for a complex explanation here.

A-c to d-c conversion equipment. Various types of conversion equipment are available, such as motor-generators, rotary converters, and tube and plate rectifiers. Maintenance men differ in opinion on the type preferred. But they all agree that proper maintenance is of utmost importance for dependable service from this very important part of a power system. No matter which type is employed, it is essential to keep equipment clean and in good operating condition.

Listed below, for example, are job-proven maintenance procedures for rotary converters.

Daily Maintenance—
(1) Check a-c and d-c voltage.
(2) Check d-c amperage.
(3) Check and record the number of automatic "trips" as indicated by the operation counter on each d-c breaker.
(4) See if bearing oil rings are turning and if oil level is high enough.
(5) Visually, check for evidence of arcing at at a-c and d-c brushes.
(6) Check temperature of bearings and machine (by hand).

Semi-Weekly Maintenance—
(1) See if a-c- and d-c brushes are loose in holders.
(2) Inspect brushes for broken shunts or broken faces.

Monthly Maintenance—
(1) Blow out machine and controls with portable electric blower.
(2) Replace worn brushes and holders.
(3) Correct tension on brushes.
(4) Inspect automatic d-c breaker.
(5) Operate all safety controls, such as bearing and frame temperature relays and overspeed devices, and test a-c d-c breaker interlocking. For test purposes try to shut off machine by using one of these safety devices.

Note: If machines are operating under dusty conditions, make monthly checks *twice a month.*

Semi-Annual Maintenance—
(1) Test overspeed device with speed indicator.

Annual Maintenance—
(1) Renew bearing oil.
(2) Megger all equipment.
(3) Test dielectric of transformer oil.

Here, also is a maintenance procedure which has proven successful in the operation of portable mercury arc rectifiers:

Daily Mainenance—
(1) Check temperature, water level and volume of air flow.

Monthly Maintenance—
(1) Blow out machine.
(2) Check reclosures for proper operation.
(3) Check water level.
(4) Check operation of all relays.
(5) Check targets.
(6) Check water strainer.
(7) Check coolant pump for leakage.
(8) Check tubes for arc-back.

Annual Maintenance
(1) Drain cooling system and flush with clear water.
(2) Inspect cooling system targets, strainer and piping and replace worn parts.
(3) Fill system with clean distilled water and add a corrosion inhibitor consisting of 0.5 percent sodium dichromate and 0.5 percent borax by weight (0.7 ounces of each per gal of water in system).
(4) Megger all equipment.

D-c feeder distribution. A d-c distribution system, made up of negative and positive components, can take various forms. The positive portion may consist of trolley and feeder or feeder only, as in conveyor belt sections. The negative portion may consist of track and feeder, or track alone, or feeder alone.

If, originally, the feeders are properly installed, they will give very little trouble. To prevent sagging, cables should be hung securely at reasonably close intervals. Where feeders parallel trolley wires, hang both from dual hangers and additional tapes will not be necessary. Also, joints are more effective if conductors are cleaned before joining. Bethlehem's experience has shown that a "thermit" weld joint is more efficient and less costly to install than solder or clamp connections. Various types of lugs or terminals are available for thermit welding (see figures 1 and 2).

Generally, better voltage can be maintained on face equipment by the use of two or more smaller cables rather than one large cable of equal cross-section. Primary reason for preference of several smaller conductors to one large conductor concerns current carrying capacity. The current carrying capacity of any wire or cable is limited by temperature rise. Since a cable is cooled by passing heat from its surface area into the surrounding air, it logically follows that the coolest feeder (and the one able to carry the most current) will be the one with the most surface area available to dissipate heat generated by the current.

For example, two lengths of 1,000,000 CM cable have the same cross-section as a single length of 2,000,000 CM cable (see figure 3). But the two lengths of smaller cable have a total surface area over 40 percent greater than the single length of large cable. Thus, the two smaller cables would be more efficient in dissipating heat and therefore could carry more current than the single large cable.

Example "A" in figure 3 points this out clearly. A single 2,000,000 CM cable is rated at 1876 amp. Two parallel 1,000,000 CM cables under the same conditions are rated at 1231 amp each or a total of 2462 amp—586 amp more than the single cable having the same cross-sectional area.

Another way to express the advantage of two smaller cables over one larger cable of equal size is in terms of voltage drop. When two smaller cables in parallel and a large cable having the same cross-sectional area are made to carry the same current, the two smaller cables will operate at a lower temperature than the larger

cable. Since the resistance of copper increases with increasing temperature, there will be less voltage drop—or higher face voltage—with the two smaller cables.

Thus, a 2,000,000 CM copper cable carrying 2462 amp will have about a 13 percent higher voltage drop than two 1,000,000 CM copper cables carrying the same current.

Trolley wire of adequate size must be used for today's high-capacity haulage locomotives. To obtain maximum life from trolley pole shoes, the trolley must be conditioned properly. A good lubricant must be applied to the trolley wire with a proper applicator. The interval between applications depends upon actual operating conditions.

Table I shows the "D-C Carrying Capacity and Resistance of Copper Trolley and Bare Feeder Wire Combinations" which can be used to check voltage drop in feeder systems.

The negative or return portion of the d-c system is no less important than the positive side.

A mistake is sometimes made in that the track is not bonded sufficiently for the amount of current the track is expected to carry.

A tabulation is given below of equivalent CM of copper for weight of rail, as well as resistance of bonded track:

Weight of Rail	Equivalent Each Rail, CM of Copper	Resistance, Ohms Per 1000 Ft (Both Rails Bonded and Cross-Bonded)
30	300,000	0.0180
40	400,000	0.0135
50	500,000	0.0108
60	600,000	0.0090
70	700,000	0.0077
80	800,000	0.0067
90	900,000	0.0060
100	1,000,000	0.0054

Track should be checked periodically for loose or broken bonds and replaced promptly if defective. Due to the rapid advancement of the face by today's mining methods and machines, distances from the substation may be greater than realized.

Trailing cable. The trailing cable delivers power to the operating machines, and, thus, must be given as much attention as any other component in a mine power system. Aside from low voltage and overload, the major causes of cable failure are excessive tension and mechanical damage. The installation of spring-type shock absorbers, as well as keeping proper hydraulic pressure on reel, will help prevent excessive tension. Also, the reel should be adjusted to prevent back spooling.

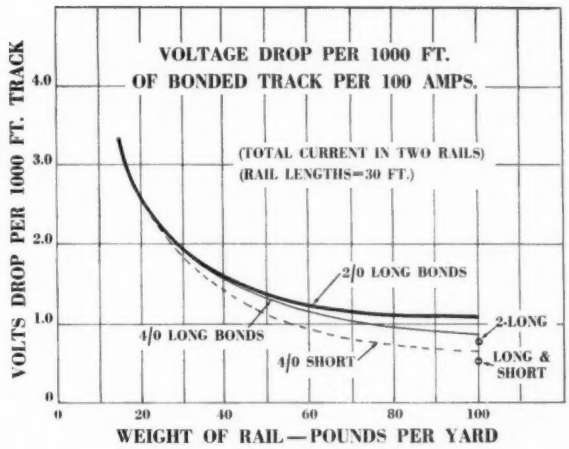


Fig. 4. The theoretical voltage drop can be calculated for each section of a mine circuit by means of the curves shown above and the data in table I

To prevent mechanical damage, avoid running over cables. Replace broken sheaves and guides. Avoid pinching cables. Clean out dirt accumulated in reel compartments on shuttle cars to prevent cable and reel from fouling. The reel compartment on some shuttle cars can be eliminated altogether.

Despite all precautions, cables will occasionally fail. To prevent excessive down-time, quick restoration of service is essential. Two ways to get equipment back to work fast are:

(1) Temporary connection. A quick temporary connection can be made simply by tying each conductor in a square knot.

(2) Spare cable. When it is difficult to locate the fault in the cable, simply use a spare and change the entire cable. Send the used cable to the shop and let them find the fault.

In general, experience has shown that a vulcanized cable with welded conductors gives satisfactory service and helps to reduce cable replacement costs.

TABLE I. D-C CARRYING CAPACITY AND RESISTANCE OF COPPER TROLLEY AND BARE FEEDER WIRE COMBINATIONS

Trolley Wire 2-0, 4-0 or Cir. Mil. Size	H. D. Bare Feeder Conductor Size in Cir. Mil.	Trolley and Feeder Wire Combined: Area in Cir. Mil.	*Safe Load in Amps	Volt Loss Per 1000 Ft Per Amp at 20° C	#Weight Lbs Per 1000 Ft
2-0	None	133,200	319	.07741	418
4-0	None	211,600	424	.05035	642
4-0	211,600	423,200	848	.02522	1,284
4-0	500,000	711,600	1,203	.01516	2,186
4-0	750,000	961,600	1,445	.01127	2,958
4-0	1,000,000	1,211,600	1,655	.00890	3,730
350,000	None	350,000	601	.03040	1,063
350,000	250,000	600,000	1,087	.01797	1,835
350,000	500,000	850,000	1,380	.01204	2,607
350,000	750,000	1,100,000	1,622	.00980	3,379
350,000	1,000,000	1,350,000	1,832	.00799	4,151
350,000	1,500,000	1,850,000	2,194	.00583	5,694
350,000	2,000,000	2,350,000	2,477	.00459	7,238
400,000	None	400,000	671	.02687	1,202
400,000	500,000	900,000	1,450	.01210	2,746
400,000	750,000	1,150,000	1,692	.009449	3,518
400,000	1,000,000	1,400,000	1,902	.007805	4,290
400,000	1,500,000	1,900,000	2,264	.005761	5,833
400,000	2,000,000	2,400,000	2,547	.004566	7,377
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6

* Safe load figures in this column are based on an ambient temperature of 15° C (59° F) and a temperature rise of 65° C (149° F) which gives a copper operating temperature of 80° C (176° F) which temperature is not excessive in case of bare conductors. An ambient temperature of 15° C (59° F) was selected as representing an average value of the air temperatures encountered inside coal mines. In case of other ambient temperature values, safe load figures in this column should be modified.

Includes trolley and feeder.

Modern Tools of Maintenance

When low voltage conditions are reported from a section or unit, the power system can be checked readily with recording instruments. Of course, the best time to install the instruments is on an idle day when the section can be isolated from the rest of the mine. A recording d-c ammeter and voltmeter should be installed at one or more locations on the system as well as at the face. By use of table I and the curves in figure 4, the theoretical voltage drop can be calculated in each section of the circuit. They can then be compared with the actual drops shown on the recording instruments. The portion of the circuit which indicates that the actual drop is much greater than calculated can then be checked thoroughly to find the real cause of low voltage, and proper steps taken to correct the condition.

Figure 5 shows an example of an actual section investigated. Various recording instruments were installed to check load and voltages. Actual and calculated drops were then compared. The drops in the trailing cable were also investigated. The results of the test indicated a need for a larger trailing cable. The cable did not get hot, but voltage drop was excessive. The test also indicated that when two Colmols, or Colmol and Miner, are used, then 2,000,000 CM positive and negative cables should be used.

System Protection

Safety, quick isolation of fault areas and prevention of major damage to equipment are three benefits of proper circuit protection in a mine power system.

Important checkpoints are given below.

(1) Substations should be equipped with automatic reclosing d-c breakers set to carry normal load conditions but to open on unusual loads.

(2) Circuit breakers equipped with an undervoltage trip device should be installed on feeders paralleling belt conveyor lines. The control circuit of the trip device could be installed on the roof parallel to the belt line. This cable only needs to be a No. 10 AWG wire installed in 100-ft lengths with push-pull connectors. If there should be a roof fall, the control line would pull apart, thereby opening the circuit breaker and removing all power from along the belt line and from the face area. Thus, if the feeders should become shorted due to the roof fall, no fire could result.

(3) Install overcurrent protection at the supply end of each circuit to pumps or other fixed loads.

(4) Install switches to cut power off unimportant and infrequently used branch or stub circuits.

(5) Cut power off all idle territories during non-operating times. If it is necessary to run a pump or some other unit, special overload protection no greater than needed should be provided. It is best that this be a circuit breaker rather than fuses, since there is less tendency to set it too high as may happen with fuses.

(6) Face equipment should be provided with ground protection for both men and machines. The solid wire from the machine frame to ground provides protection to men from short circuits under most conditions, but affords no protection to the machine. Thus, some other provision is necessary. A good answer to this is the use of a three-pole circuit breaker, with one pole in the grounding circuit equipped with an adjustable current limiting relay. A low-intensity fault will trip the breaker as a signal for corrective measures, while a high intensity fault will be cut off before severe equipment damage occurs.

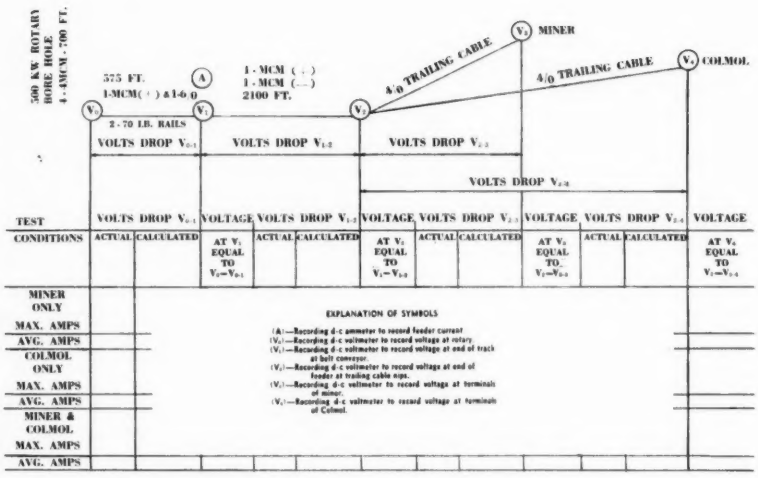


Fig. 5. Typical test set-up for mine power system. The drawing shows where various recording instruments were installed to check load and voltages

INDUSTRIAL ENGINEERING

(Continued from page 32)

grams. In this light, then, it is of benefit not only to management but to labor, in that it preserves jobs overall by helping the company continue to make a profit; it benefits communities by helping to keep the mining enterprise in a stable condition; and it aids the country by giving the domestic mining industry a valuable weapon with which to fight increasing low-cost foreign competition.

More I. E.'s Needed in Mining

In conclusion, we have shown broadly how I. E. is used by 23 mining operations. It is evident that the mining industry has been slow to use this cost cutting tool, and that even where used, its full potential has not been fully realized.

In addition, the mining industry in many cases has not recognized the professional nature of I. E. work. The industrial engineer in mining needs not only the usual background in mining, metallurgical, or mechanical engineering, but requires training in accounting, statistics, business administration, management, higher mathematics, computer programming, and knowledge of the specialized techniques that have been built up as part of the industrial engineer's weapons against rising costs.

The mining industry in general is attempting to take a shortcut by trying to do a professional job with inadequate use of professionals. Professionally trained industrial engineers are needed in larger numbers to augment the staffs of technicians and engineers with other backgrounds.

The curricula of mining schools should include basic I. E. courses, because unless a mining property can continue to operate at a profit, it is obvious that there will not be a place for the mining engineer to practice his profession.

We have defined I. E. as used in the mining industry by indicating the type and scope of work performed, the type of personnel used now and needed in the future, the importance of line cooperation, and the part consultants play. Most important of all, we have emphasized that industrial engineering can only reach its maximum effectiveness when it is actively used by management as a tool to help manage.

The authors wish to thank the 23 mining operations that cooperated in this survey for their frank and open discussions of their use of industrial engineering. Without their understanding and willingness to contribute, this survey could not have been made. Their cooperation stands as a symbol of the free interchange of information that exists in the mining industry despite its competitive nature.

MINING HUGE ORE BODIES IN SWEDEN

Four modern iron ore operations are currently deep mining 21 million tons of ore per year. Plans call for a 33 percent increase

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THIS article deals with ore bodies in Sweden from which the annual extraction exceeds 1,000,000 tons — Kiruna, Malmberget, Grängesberg and Stråssa.

Underground mining requires more labor and is more difficult to mechanize than surface mining, but in Sweden great efforts have been made to rationalize the underground opertions by mechanization, remote control, automation, etc.

The table below gives the hoisting capacity of the mines mentioned.

Mine	Million Tons Hoisted Per Year	
	Present	Planned
Kiruna	12.6	15
Malmberget	4.73	8.5
Grängesberg	2.75	3.2
Strássa	1.2	1.6

All the ore bodies are steep, having a dip ranging from 50 to 70°, and extend to great depths. The Kiruna deposit, for instance, is assumed to reach to a depth below 4500 ft. Difficulties will therefore be experienced in connection with the future mining operations considering the rock pressure, hoisting problem, etc.

Sublevel Caving at Kiruna

Because of the different ore grades at Kiruna, with wide variations in phosphorus content, selective mining is practiced. Of course, the advantages of such mining have to be weighed against the higher mining costs involved.

Mining methods which have been discussed at Kiruna are block caving, shrinkage stoping, long-hole mining and sublevel caving. Up to the present, it has been impossible to use block caving owing to the comparatively high strength of the ore and the low rock pressure. Shrinkage stoping and long-hole mining cannot be practiced with advantage due to the mixture of different ore grades. After close consideration, the sublevel caving method has therefore been adopted, which to a certain extent has made selective mining and mechanization possible.

Taking into account the volume and regular structure of the ore deposit, the major problems are those connected with the mining method used including drifting. Next in importance are those associated with loading and haulage on the mining levels, transport on the haulage level, and rock hoisting.

Improved Drilling Practices Increased Production

In connection with efforts to determine the most efficient sublevel caving method, calculations and model tests, to establish the most economic drift area, pillar width, slice-height, etc., have been made.

Methods used in both drift and fan-hole drilling in the slices have been closely investigated. For example, in a 12 by 16-ft drift, an ordinary V-cut, is less expensive than a parallel-hole cut.

Today, drifting is done essentially with Atlas Copco pneumatic-pusher rock drills* RH-656 and BBC-22 and with Joy Drillmobiles incorporating Model BBC-43 rock drills.

In its simplest form, sublevel fan-hole drilling is done with a supporting arch used as a hole director.

** Unless otherwise specified, rock drills discussed herein are of the Atlas Copco brand.*



Fig. 1. Blast holes are drilled in a fan-shaped pattern from a mobile drill wagon at an underground mine in Sweden

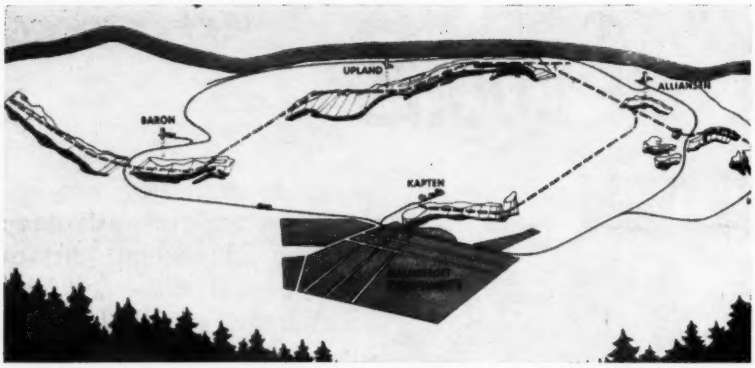


Fig. 2. The economics of mining small ore bodies, that vary as to area, dip, and strength, has led to the application of block caving, long-hole mining, shrinkage stoping, and sublevel caving at Malmberget

Mechanized drilling with two rock drills per unit is undertaken with drill wagons BUK-21K and BUX-37.

The rate of penetration has advanced from about 160 ft per man-shift with rock drill BBD-46-WS8 to about 330 ft with BUK-21 and about 530 ft with BUX-37. It may be possible to reach a footage of about 650 per man-shift with the latter machine.

With larger drill holes and larger burdens as well as more accurate drill hole bearings, rock removal, in tons per foot of hole drilled, has risen from about 1.5 to 4.5. The amount of ore obtained per man-shift has risen from about 500 to nearly 3000 tons by the above-mentioned measures. One of the most important factors in this connection is the location and bearing of the drill holes in the fan.

Haulage Operations Under Study

Loading and transport of the ore are essentially undertaken with electrically driven loaders and shuttle cars. With a new type of crawler-mounted loader, fitted with a two cu yd bucket, a capacity of 1000 tons per shift has been recorded in connection with truck haulage. An interesting diesel-driven hauling truck, known as the Kiruna truck, has been developed and found to involve lower working costs than shuttle cars.

Haulage to the hoisting shaft is undertaken with 20-ton cars of the Malmberg type, and the trains are conducted throughout by means of a centralized train control (CTC) plant. Investigations are being made to determine whether the haulage capacity can be calculated and the trains directed by means of a data processing machine. The possibility of transporting ore from the sublevel drifts directly to the hoisting shaft by means of trucks is also being investigated.

Hoisting is mainly centralized at a point where nine 4-rope ASEA Koepe hoists with 20-ton skips, having a total hoisting capacity of 20,000 tons per shift, are in operation.

The transport of men and material from the surface to the mine is trackless. It takes place in an inclined tunnel to a depth of 1200 ft, permitting the miners to go by bus directly from their change-room to a point near the working place.



Fig. 3. Operator at underground control station directs discharge of trucks, operation of the coarse crusher, feeders, measuring bins, skips, and discharge of ore into railway cars

Haulage at Malmberget is Complicated

As distinguished from Kiruna, Malmberget consists of several small ore bodies which make the haulage—both horizontally and vertically—especially complicated, the more as different ore bodies are being excavated on different levels. Haulage is the most important economic factor —next come the development operations and the mining methods.

Ore bodies at Malmberget vary considerably as to area, dip and strength properties, which has led to the application of various mining methods. From an economic point of view, it has been found advisable to use different methods, when possible, in the following order: block caving, long-hole mining, shrinkage stoping, and sublevel caving.

Block caving is practiced in the "Kaptenslargret" where level development is facilitated by means of truck transport to the underground crusher. Mining by the ring drilling method takes place from a central drift in the ore, and long-hole drilling is undertaken with Model BBC-52-RFL hammer drills using extension steels. The drilling rate is about 130 ft per shift.

Shrinkage stoping is practiced in narrow ore bodies. It is also undertaken in transverse stopes with 16-ft workings and 16-ft pillars in large ore bodies where the strength of the rock does not permit long hole mining in open stopes.

Sublevel caving is used only in flat-lying, irregular bodies with low strength of ore or hanging wall.

Raises Driven Five Ft Per Man-Shift

Drifting is extensive at Malmberget and has been carefully investigated. Besides pusher-fed rock drills, a spe-

cial unit, BUX-13, has been adopted for drilling the parallel holes in connection with opening up of the face. This unit incorporates a model BBC-51 drill for drilling a four-in. central hole and two BBC-43 drills for drilling 1¼-in. parallel holes. The feed length is 20 ft, but the most economic rate of advance per round is about 13 ft. In the drifting operations, holes are drilled by means of a self-propelled Drillmobile equipped with two BBC-43 drills using 1¼-in. steel.

Raising is mostly undertaken with Alimak raise climbers which enable raises, 300 ft in height, to be easily driven. The average output amounts to about five ft per man-shift.

In connection with the sublevel caving, mucking is with LM-100 loaders and U3N shuttle dumpers. A change is being made to trackless haulage by means of a combined loader and hauling truck of Swedish design.

From the shrinkage stopes, the ore is most economically removed through large chutes of Malmberg type. The chuting rate is about 800 tons a shift.

Horizontal haulage on the main level is very complicated, there being several hundred loading points for a distance of four miles. Haulage to the crushing plant below ground is by means of a special type Malmberg car of 20-ton capacity. A train comprises 15 cars and is hauled by a 20-ton contact locomotive. This haulage is completely controlled from a CTC plant. Weighing of the cars is automatic.

One Man Operates Hoisting Plant

Because the haulage system at Malmberget is complicated, a central plant for conducting both horizontal and vertical transport, enabling efficient use of the cars, locomotives, skips, bins, etc., is now being considered. Today, the haulage system includes 60 ore bins and 70 stationing places for ore trains. A data processing machine is probably suitable for directing haulage with this layout.

Battery locomotives arranged for remote control are used at loading points for shunting the ore cars.

The ore is hoisted by means of skips. The "Kaptenschaktet" is an example of a completely automatic hoisting plant. This shaft is equipped with two 4-rope friction hoists. The whole hoisting plant consists of: A coarse crusher, with distributing door, 1700 ft below the surface; two crusher bins, each having a capacity of 590 cu yd; a skip filling station, with measuring bins 1850 ft below the surface; a skip discharge with reversible door, 860 ft below the surface; two 545-yd capacity skip bins; and a drawing station for railway cars, 1000 ft below the surface.

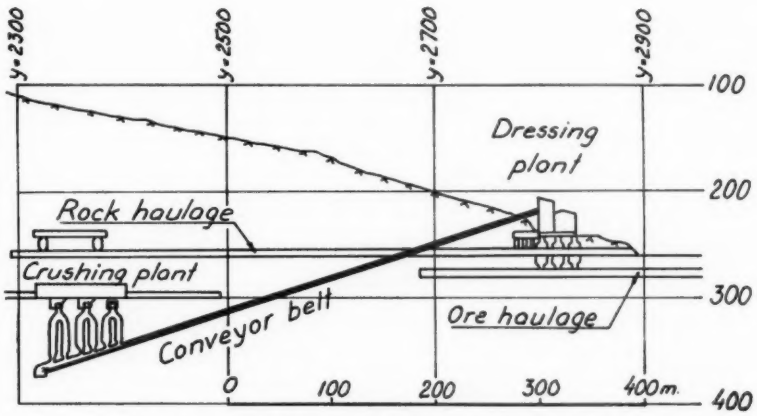


Fig. 4. Four 600-tph capacity rubber-covered steel conveyors move ore from the underground crushing plant to the mill at Malmberget

This plant is worked by one man from an operating room adjacent to the skip fiilling station. Moreover, with the aid of indicator lamps and four television sets, this man supervises the discharge of the trucks and operation of the coarse crusher, feeders, measuring bins, and skips. He also handles the discharge into the railway cars (figure 3).

All ore is hauled to a crushing station equipped with three gyratory crushers, from which the haulage to the ore dressing plant is effected by means of four Sandvik rubber-covered steel conveyors. The haulage distance is 1600 ft, the incline in 16.5°, and the capacity per conveyor is 600 tph (figure 4).

Block Caving Practiced at Grängesberg

Grängesberg has one large ore body and several small parallel ore bodies. Sublevel caving has been extensively used in this mine, and shrinkage stoping has been practiced on a small scale. At deep levels a change has been made to block caving, which at present accounts for 50 percent of the ore production and will be increased to about 75 percent.

The block now being worked contains about three million tons of ore. Its height is 150 ft. The ore is discharged by means of LM-100 loaders into 2.6-cu yd Granby cars which are either driven by six hp air motors fitted with trailing hoses or transported by an accumulator locomotive. In block caving, the loss of ore is estimated at about six percent and the waste rock in the ore is about ten percent.

Sublevel caving drift dimensions have been increased from 6.3 by 7.3 ft to 7.3 by 8.3 ft, and the slice height has been increased to 21 ft. In this method, the loss of ore is about 10 percent and the waste rock in the ore is about 15 percent. Loading is undertaken with LM-30 loaders and U2N shuttle dumpers. The loading capacity is about 175 tons per man-shift.

A comparison of the production in sublevel caving per worker year with the corresponding production in block caving gives about 40,000 tons and 56,000 tons, respectively, calculated on the staff of miners.

In development work, drilling is done with Model RH-656-4W pneumatic-pusher rock drills, and the rock face is opened by parallel-hole blasting against two holes that are drilled close together, instead of one large hole. This method works well, and both parallel and fan-hole drilling is done with a single machine.

Haulage to the underground crusher is effected with 20-ton cars of the Malmberg type. A special type of discharge device automatically opens and closes the car bottom during forward motion of the train. The train is advanced by the force of reaction produced by the movement of the bottom of the loaded car when it is emptied (figure 5).

Hoisting is by push-button operated Koepe hoists and 15-ton skips. The total output reckoned on all miners below ground is about 37 tons per manshift.

Level Benching at Strässa

Strässa is a mine situated about 22 miles south of Grangesberg. It is of old standing, but it has been completely rebuilt. Even though the haulage level is only about 260 ft below

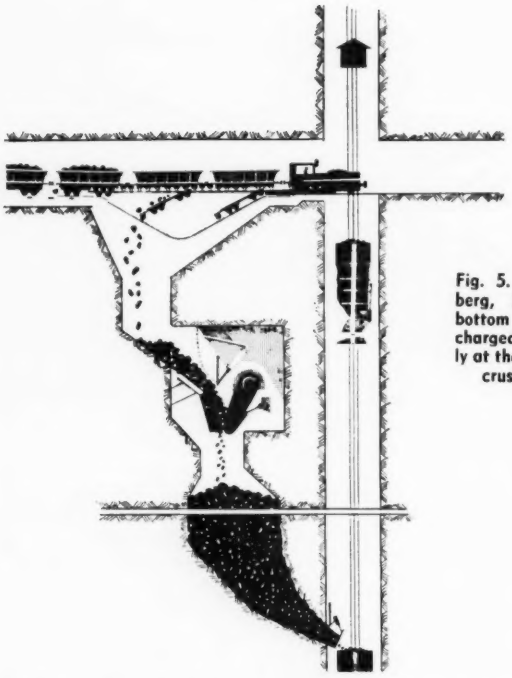


Fig. 5. At Grängesberg, 20-ton drop-bottom cars are discharged automatically at the underground crushing plant

ground, underground mining continues to be practiced due to past completion of a certain amount of development work and the existence of previously driven haulage drifts. The ore at Stråssa is low in grade and is easily concentrated.

In selecting the mining method, special attention has been given to such factors as mechanized drilling, new charging methods and boulder control during loading.

The mining method, known as level benching, is fairly unique, for drilling is done vertically from above and as upward fan drilling (figure 6).

From a gallery drift on the haulage level, transverse haulageways are driven every 80 ft, and the drilling drifts are driven between these. Loading is done in short communication drifts between the drilling and haulage drifts.

Benching is undertaken with BVB-23 drill wagons and BBC-52-RBL drills using 1¼-in. steel and two-in. bits. The footage per shift is about 230.

Fan drilling from below is done with units incorporating two 6-ft screw feeds and with rock drills using 1¼-in. drill steel and two-in. bits. In the future, it is expected possible to drill straight holes up to 150 ft in length and from 2 in. to 2½ in. in diameter. The vertical distance between the main haulage levels will probably be increased to 200 ft.

Loading is with Swedish-built loaders discharging into six-cu yd Granby cars. The loading capacity is about 400 tons a shift.

The transport to the haulage level is push-button operated and essentially automatic. The accumulator locomotives are operated at chutes and at the crushing plant by wireless via an antenna under the rails. Hoisting, which is fully automatic, is effected with a four-rope Koepe hoist equipped with 15-ton skips and counterweights.

The actual quantity of ore raised per man-year is about 34,000 tons. If everyone below ground is included, the rate is 8300 tons per man-year or 36 tons per man-shift.

Advances in Methods and Equipment Continue

Although manually operated, pneumatic-pusher drills are still economic, especially when used in small drifts and stopes. Several improvements have been made on feeds, including those of the simple "ladder" type. In bench drilling, the Model BMP-31 has proved efficient.

In deep hole drilling, screw feeds and comparatively powerful rock drills are invariably used. These drills are extensively operated with light drill steels carrying a 1¼-in. thread. In operations of this kind, it is most important that the holes are straight. At Stråssa, for example, a hole deflection of only seven ft has been recorded when drilling 170-ft holes. To ensure efficient dust removal and a high drilling rate, the flushing holes have been increased in size.

In the field of blasting, particular interest has been devoted to ammonium nitrate. Today, various mines use ammonium nitrate below ground and in holes 1¼ in. in diameter and 50 to 70 ft in depth. Experiments are being continued to establish proper procedures relative to initiation, detonation stability, etc.

For charging upward holes with powdered explosives, several types of charging units have been developed. With such a device, two men can charge as much as 1800 lb of ammonium nitrate per shift into fan-drilled holes 50 by 2 in. diameter.

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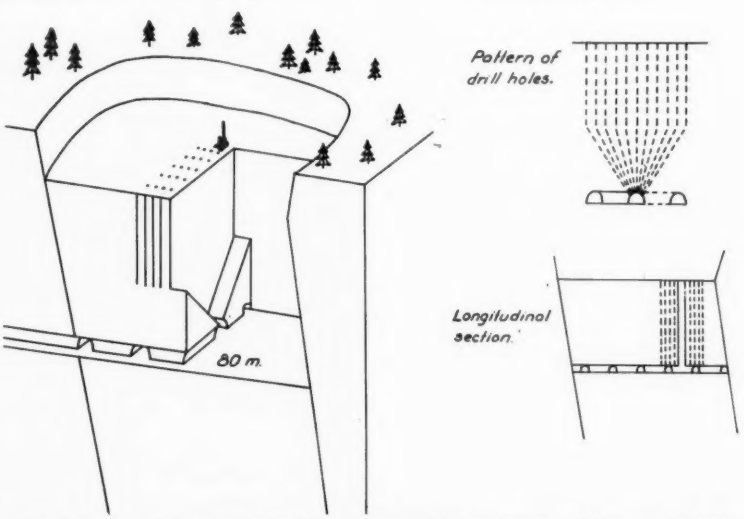


Fig. 6. Stopes at Strassa are drilled from above and below. The down holes are vertical and the up holes are fanned out to form a hopper-like stope floor after blasting

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Fig. 1. Ripping can not only eliminate or reduce blasting costs but it can, under certain conditions, reduce the over-all cost of moving overburden

Bulldozers as a Supplemental Tool to Stripping Shovels and Draglines

To what extent should bulldozers be used in conjunction with other types of earth-moving machinery?

OVER the past dozen years, there has been an obvious trend toward larger stripping machinery in the bituminous coal fields. Larger shovels and draglines are more and more commonly accepted. At the same time, there has generally been an increased use of bulldozers for overburden removal. The purpose of this article is to discuss the theory and reasons for bulldozer usage in conjunction with revolving excavators.

Of course, there are so many variables in coal stripping operations which affect the choice and method of use of both types of machinery, ranging from jobs where it is practical to use the dozer alone to others where the dozer is at best a utility tool, that all instances cannot be covered in the space allotted. Rather, the ideas contained here shall be concerned with situations where there is an economic need for both types of earthmoving machinery, and will attempt to show the limits and advantages of each.

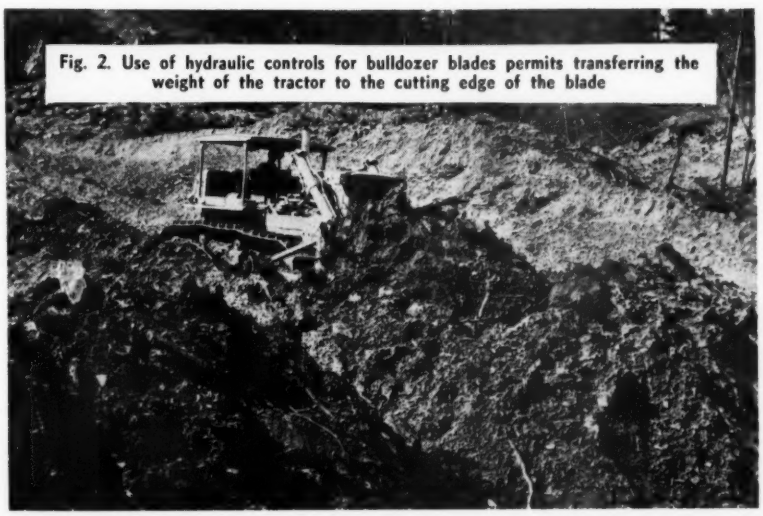


Fig. 2. Use of hydraulic controls for bulldozer blades permits transferring the weight of the tractor to the cutting edge of the blade

Improvements Increase Usefulness of Bulldozers

Among the advances that have added to the productivity and usefulness of bulldozers in open pit mining opera-



Fig. 3. A tilt cylinder increases the versatility of a bulldozer by making easier such jobs as benching or side hill cutting, digging diversion ditches and cutting tree roots

tions, much credit can be given to the increased use of hydraulic equipment and attachments. Some items which stand out in this respect are the hydraulic tractor-mounted ripper, the hydraulically operated bulldozer blade, the hydraulically operated tilt cylinder, and new developments in power shift transmissions. The U-shaped bulldozer blade and the giant sized tractor are other major advances, though not necessarily hydraulic, which have increased the abilities of bulldozers.

Tractor mounted ripper. Ripping is certainly not a new idea. Rooters or rippers have been manufactured for years and have been utilized by many strippers and contractors, principally as utility tools, with the hope that they could reduce blasting costs. However, with the advent of the crawler-mounted ripper, ripping became more of a primary function than before. The crawler-mounted unit has many advantages over the former model; it is not as cumbersome and does not reduce the mobility of the tractor. Tight turns can be made as easily as if the ripper were not there. Actually, some people feel that the added weight of the ripper increases the traction of the crawlers, thereby increasing the productivity of the machine as a bulldozer. When in use, the crawler-mounted ripper has the distinct advantage of having the weight of the tractor added to it, giving much more penetration than the former, tractor drawn model, and increasing its ability to rip hard material.

It is felt by many that the cost of ripping rock or shale should seldom exceed five cents per cu yd. It is figured this way. Assume a very large tractor with tractor-mounted ripper, which costs maybe $22.50 per hour to operate. This machine has a first gear speed of 150 fpm (50 linear yd per minute). Assume the material to be ripped is so tough that it can be ripped only at a speed of 90 fpm (30 linear yd per minute). The teeth can penetrate to a depth of 28 in., but assume once again that the material is so hard that the ripping depth is only 12 in. (1/3 yd). It is possible to pull as many as three teeth. Assume only one tooth ripping material one yd in width. Then, production would be 30 yd per minute times 1/3 yd (depth) times 1 yd (width) equals 10 cu yd per minute. Assume only 75 percent efficiency. Hourly production would then be 45 minutes times 10 cu yd per minute equals 450 cu yd per hour.

Under these conditions, it would seem that the material is so hard to rip that this method would be impractical or impossible if the material were any harder. Cost per cubic yard for ripping would be $22.50/450 cu yd per hour equals 5¢ per cu yd. This should be close to the maximum cost for means other than ripping should be considered to break any harder material.

Ripping can not only eliminate or reduce blasting costs, but it can, under certain conditions, reduce the over-all cost of moving overburden for the following reasons. As will be brought out later, there is usually a portion of dirt on some stripping operations that can be moved most economically by the bulldozer. But in some of these situations, the dozer has to go through a hard layer of material which is difficult to cut and the dozing principle is limited. If this material can be ripped, the dozer can proceed to cut to its most economical depth, contributing to a lower over-all cost of removing overburden.

Hydraulic controls for bulldozer blades. Hydraulic controls are certainly nothing new in the bulldozer industry. However, in recent years they have been greatly improved, not only in their ability to exert down pressure on the cutting edge of a blade, but also in reducing mainteance costs and downtime resulting from imperfect design. Today they are very much accepted in the bituminous coal stripping fields.

The hydraulically operated bulldozer blade is not always at an advantage over other types, but there are some situations where it does have a definite edge. Layers of frost, hardpan, or shale can sometimes be cut and removed with ease if down pressure can be applied to the blade. The hydraulically operated blade can do this because of its ability to transfer the weight of the tractor to the cutting edge of the blade. A blade that depends on its weight alone to cut the ground would be at a disadvantage. Examples can be given where tests showed a smaller dozer was equal, and in some instances superior, to a large machine because a hydraulically operated blade made the smaller unit superior in hard cutting material.

The hydraulic blade tilt. A foot or hand operated device called the tilt cylinder enables the bulldozer operator to change the position of the blade so that one corner of the blade can be two to three feet below the other corner. It increases the versatility of a bulldozer by making easier such jobs as benching or side hill cutting, digging diversion ditches, cutting tree roots, and helping blade penetration in hard cutting material. Many dozer operators are instructed by owners to use the tilt device as a method of steering the tractor when it is working under load. It is their experience that maintenance costs are greatly reduced, especially to the steering mechanisms of the tractor.

Power shift transmissions. In bulldozers of not too long ago, the common power reduction and speed selection device was a flywheel clutch and direct drive transmission. This was generally so difficult to operate that all available speeds and working ranges of the machines were not used to the utmost, or the operator suffered from fatigue and was not at his topmost efficiency. Many improvements have been made in this type of drive for bulldozers to make it economical and easy to operate, and it is still very much accepted for coal stripping applications. However, the trend toward mechanical rather than manual operation should not be ignored.

Many advances in the use of hydraulic torque convertors and the planetary gearing method of speed change and power reduction have been made. Today it is possible to have a machine with no flywheel clutch or clutch controls, a machine which can be shifted under load through all speed ranges, including forward and reverse, as easily as shifting from forward to reverse in the

automatic transmission of a car.

New designs in bulldozer blades. Much has been learned and advanced in the design of moldboards for bulldozer blades to increase the amount of dirt that can be pushed in a single pass. One example of this is the U-shaped blade which has lately become quite prominent in production bulldozing jobs. This particular blade reduces end spillage and is believed to carry more dirt in the pocket formed by the U. Thus, the amount of cubic yards removed with this blade during each pass of the dozer is considerably increased over former models available.

Increased size of bulldozers. It is a generally accepted fact that a large earthmoving machine can perform a unit of work cheaper than a smaller one provided it is balanced, not only from the point of view of horsepower to weight and traction, but also in the sense that maintenance costs and downtime are reasonable, that good parts and service facilities are available, and that there is enough work available to keep it reasonably busy.

It is obvious to anyone familiar with the progress of bulldozers in recent years that all manufacturers have been stepping up their products in size and performance. The Euclid Division of General Motors Corp. has started to manufacture a relatively new line of large tractors. Allis-Chalmers has gone from the HD19 to the HD20 and now the HD21, each machine larger and capable of better performance than its predecessor. International Harvester Co. brought out the TD24 and now has replaced it with a more powerful TD25 model. Caterpillar Tractor Company's D8 has gone through several series, from the 1H, followed by the 8R, then the 2U, 13A, 14A, and now the Series H machine, which is easily twice the tractor as some of its earlier predecessors in performance. In recent years the Cat D9 was introduced, an entirely new addition to this manufacturer's line of equipment. Tests have shown that the additional investment and operating cost of this large machine is more than justified by the increased production over its smaller "brothers."

Estimated Operating Costs

Rather than arbitrarily establish methods to determine hourly operating costs for machines, this discussion will use methods for determining costs of bulldozers and methods for determining costs of revolving excavators that are acceptable to each industry.

For example, bulldozer manufacturers generally establish the life of such machines at 10,000 hours for purposes of determining depreciation costs. Actually, it would be a very unusual case where a bulldozer would completely lose its value in this short period of time. However, shovel manufacturers, using a method prescribed by the Power Crane and Shovel Association, estimate a life of 30,000 operating hours for a five-yd dragline, and experience has shown that this too would be a very unusually short life for such a machine. Let us say that even though both of these methods tend to give a less favorable depreciation cost than actually exists, that at least the ratios between the two types of machinery depreciation periods (that is, 3 to 1) are in the neighborhood of being acceptable.

With this in mind, let us establish the hourly operating cost of a 300+ hp bulldozer with an approximate purchase price of $60,000 and a 5-yd, 90-ft boom dragline with an approximate purchase price of $165,000 as an example of the methods of estimating hourly costs.

	Bulldozer	Dragline
Depreciation		
10,000 hours	$ 6.00/hour	
30,000 hours		$ 5.50/hour
*Interest**		
6% on average investment 2,000 hours per year	0.97	2.47
Accrued Maintenance		
90% of depreciation	5.40	
80% of depreciation		4.40
Lubrication	0.30	0.23
Fuel	1.80	1.65
Operator (estimated)	3.50	3.50
Oiler (estimated)		2.50
	$17.97	$20.25

* Interest is either paid or could be gained if money were invested elsewhere.

It is generally claimed that the owning and operating cost relative to amount of investment of large draglines is very favorable compared to bulldozers and it should be noted that these methods of cost estimating certainly take this into account.

Production and Cost Per Cubic Yard of Overburden

Dragline. Continuing to use the example of the five-yd dragline, for which the hourly cost of operation was estimated above, it would follow that if average hourly production can be established, the cost per cubic yard of overburden can also be established. The machine described should, under most conditions, have a cycle time of approximately 40 seconds. This is reasonably fast because of the relatively short boom (90 ft) and also the favorable horsepower ratio available in a particular machine of this size. It is possible that larger, longer boomed draglines experience a longer cycle time, resulting in less favorable cost per yard of overburden. However, using this example and such safety factors as a 50-minute hour, and a 75 percent bucket factor, average hourly production can be anticipated as follows:

Average cycle time	40 seconds
Swings per 50-minute hour	75
Bucket capacity	5 cu yd
Bucket factor	75% =
Bucket capacity (solid yards)	3.75 cu yd
Average hourly anticipated production 3.75 cu yd × 75 swings/hour =	281 solid cu yd
Cost per yard = $\frac{\$20.25}{281 \text{ cu yd/hour}}$	7.2¢

Bulldozers. Using the same bulldozer as an example as the one above for which the hourly costs have been estimated, and assuming that the material to be moved is of a nature that can be dozed or ripped and dozed, average hourly production can be established according to terrain conditions on which the machine is expected to work.

This bulldozer should be expected to approximate the following performance:

Grade	Blade Loads	Push Speed*
Up 10%	5.3 cu yd (solid)	155 fpm
Level	7.5 " " "	165 "
Down 20%	14.5 " " "	175 "

* *Variation in speed due to track slippage.*

so that production and cost per yd for a 100-ft push would be:

Up 10% Grade	
Push—100 ft @ 155 fpm	0.65 min.
Shift	0.05
Reverse—100 ft @ 350 fpm	0.30
Shift	0.05
Total cycle time	1.05 min.
Pushes/50-min. hour	47.5
Solid cu yd/push	5.3
Solid cu yd/hour	252
Estimated cost/hour	$17.97
Cost/cu yd	7.1¢
Level Grade	
Push—100 ft @ 165 fpm	0.60 min.
Shift	0.05
Reverse—100 ft @ 350 fpm	0.30
Shift	0.05
Total cycle time	1.00 min.
Pushes/50-min. hour	50
Solid cu yd/push	7.5
Solid cu yd/50-min. hour	375
Estimated cost/hour	$17.97
Cost/cu yd	4.8¢
Down 20% Grade	
Push—100 ft @ 175 fpm	0.57 min.
Shift	0.05
Reverse—100 ft @ 300 fpm	0.33
Shift	0.05
Total cycle time	1.00 min.
Pushes/50-min. hour	50
Solid cu yd/push	14.5
Solid cu yd/50-min. hour	725
Estimated cost/hour	$17.97
Cost/cu yd	2.5¢

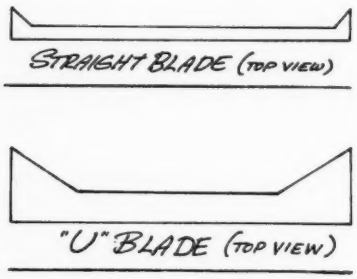


Fig. 4. Advantages claimed for the U-shaped blade include reduced end spillage and the ability to carry more dirt in the pocket formed by the U

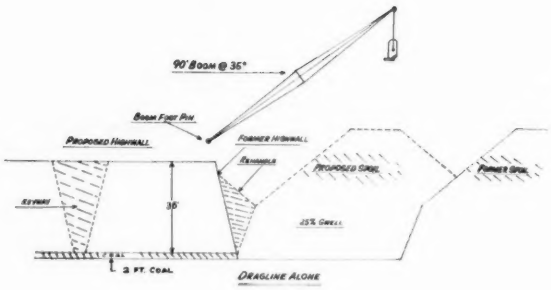


Fig. 5. Situation I—Dragline alone. Cost per ton for operating the dragline under the conditions described in the text would be $1.38

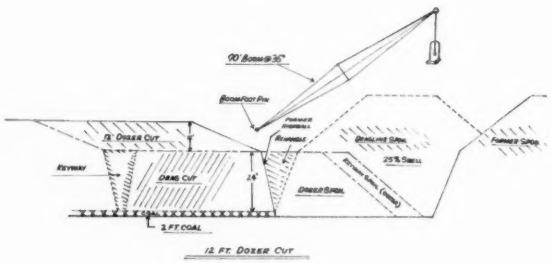


Fig. 6. Situation II—Dozer used to remove the top third of the cover. In this case, the total cost per ton for both machines would be $1.21

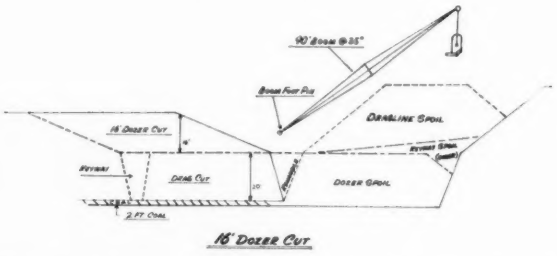


Fig. 7. Situation III—Dozer removed 16 ft. Total cost per ton for both the dozer and the dragline would be $1.20

It should be obvious from these calculations that terrain conditions can make a tremendous difference in the performance and cost of work done by a bulldozer. On the uphill push the cost per yard is 7.1 cents, which is approximately the same as that of the five-yd dragline given in the other example. If the two machines were being worked together, the dozer should theoretically not be worked beyond a push distance of 100 ft because its cost would exceed that of the drag. But if it was working downhill, it could push a considerably greater distance and still do a more profitable job.

Theory of Dozer and Dragline Used Together

Determining the proper extent to which a dozer should be used is not as easy, however, as these figures may seem to indicate. The difficulty is that grade conditions for a dozer change as its work progresses, and calculation must be made with these changes in mind.

Following is an example which approximates a common overburden to coal relationship. Assume that an overburden material of a nature which can be removed either by the dozer or dragline is 36 ft in depth and covers two ft of coal. Also assume three methods of overburden removal; first, that the five-yd dragline alone removes all of the cover; second, the bulldozer removes 12 ft (33 percent) of the cover; and finally, the dozer removes 16 ft (44 percent). The purpose of these examples is to show the relationship of the cost and production of work done by these two machines under the described conditions.

Situation I—Dragline alone. Assuming one cu yd of coal weighs one ton, to ease calculations, then the overburden ratio is 18 cu yd per ton of coal. If a 65-ft wide cut is to be made, it is probable that the overburden removed from the keyway will have to be rehandled as shown in figure 5. This rehandle material can be determined in terms of overburden ratio at 1.1 cu yd per ton of coal, making the total overburden ratio 19.1 cu yd per ton. A five-yard dragline realizing a production of 281 yd per hour, as shown previously, should then uncover coal at a rate of $\frac{281 \text{ yd/hour}}{19.1 \text{ yd/ton}} = 14.7$ tph. The cost per ton for operating the dragline would be $\frac{\$20.25/\text{hour}}{14.7 \text{ tph}} = \$1.38$ per ton.

Situation II—Dozer removes 12 ft in advance of dragline. Again considering a 65-ft wide cut, if the dozer were to take off the top third of the cover, the overburden ratio would be six-yd per ton (see figure 6). It would also be required to push away the keyway which amounts to 1.9 cu yd per ton so that the total overburden ratio would be 7.9 cu yd per ton for the dozer. The average push distance would be 20 ft on 40 percent downhill, 45 ft level, and 25 ft level for the keyway. The average production for this work should exceed 535 bank yd per 50-minute hour, because of the favorable grades and short push distance. Production in terms of coal, therefore, would be $\frac{535 \text{ yd/hour}}{7.9 \text{ yd/ton}} = 67$ tph benched by the dozer. The cost per ton for this dozer work would be $\frac{\$17.97/\text{hour}}{67 \text{ tph}} = 28¢$.

There would remain 24 ft of cover to be taken by the dragline, a 12 yd to 1 ton ratio plus rehandle of 0.9 yd per ton, or 12.9 total. Working at a rate of 281 cu yd per hour, the drag should uncover $\frac{281 \text{ cu yd/hour}}{12.9 \text{ cu yd/ton}} = 21.7$ tph. This is an increase of seven tph (47 percent) over the previous example where the dragline did all the work.

The cost per ton of coal uncovered by the dragline should be $\frac{\$20.25/\text{hour}}{21.7 \text{ tph}} = 93¢$. The total cost per ton for both machines should be 93 cents (drag) plus 28 cents (dozer) = $1.21 per ton, a decrease of 17 cents from the previous example, where the dragline worked without dozer assistance.

Situation III—Dozer removes 16 ft. If the dozer attempts to remove 16

ft of the total 36 ft of cover (figure 7), its average push distance required to make a 65-ft cut would be:

24 ft on 40 percent downhill
60 ft on level
55 ft on 5 percent uphill, (keyway rehandle)

The overburden ratio would be eight cu yd per ton plus 1.55 cu yd per ton (rehandle keyway), or 9.55 yd per ton, total. The push distance is still relatively short because of the 65-ft cut, so that average bulldozer production is 408 bank yd per hour. However, the hourly production of the dozer, not counting keyway rehandle, would be 325 yd per hour, resulting in cost per yd of overburden of $\frac{\$17.97/\text{hour}}{325\ \text{yd/hour}} = 5.6¢$. This is approaching the cost per yd of overburden handled by the dragline, and means that theoretically the dozer is near its economical limit.

Production of the dozer in terms of coal would be $\frac{408\ \text{cu yd/hour}}{9.55\ \text{cu yd/ton}}$ or 42.5 tph. Cost per ton for the dozer would be $\frac{\$17.97/\text{hour}}{42.3\ \text{tph}} = 43¢$.

Dragline overburden ratio would be 10.6 yd per ton, including rehandle, so that production of coal would be $\frac{281\ \text{cu yd/hour}}{10.6\ \text{cu yd/ton}}$ equals 26.5 tph at a cost of $\frac{\$20.25/\text{hour}}{26.5\ \text{tph}}$ or 77¢ per ton. Total cost for the dozer and drag would be 77¢ (drag) plus 43¢ (dozer) = $1.20 per ton of coal.

One purpose of this example was to show that it is possible to plan a stripping operation in advance, and to come reasonably close in determining the extent to which dozers should be used in conjunction with other types of machinery. The results showed:

	Coal Production	Cost Per Ton
Dragline alone	14.7 tph	$1.38
12-ft dozer cut	21.7 tph (47% increase)	$1.21
16-ft dozer cut	26.5 tph (80% increase)	$1.20

In this case, the dozer contributes greatly to coal production. It also helps reduce the cost per ton when cutting to a depth of 12 ft (33 percent of the overburden). If it were to cut deeper than 16 ft (44 percent) production would continue to increase but also cost per ton. In reality actual job conditions might dictate that the dozer not be used to this extent because of other work assigned to it.

ROOF CONTROL*

Eliminate Causes of Roof Falls

Roof fall accidents involve so many different factors that the job of preventing them may seem to be a difficult task. It is true of roof falls, as with other mine accidents, that some unsafe conditions and practices cause the large majority of accidents of one kind. It follows, therefore, that the mine supervisor who concentrates his efforts on eliminating the principal causes of roof falls, becomes the one most likely to prevent injuries. He puts his time and effort where they count most!

Effort directed at the elimination of the principal causes of roof falls pays big dividends. When a supervisor trains his men in safe practices of major importance, experience has shown that the training carries over into safe practices of all types.

An analysis of hundreds of fatal roof fall accidents discloses that ignoring the bolting or timbering plan is the cause in about 55 percent of roof fall deaths. Obviously, then, one of the greatest contributions a supervisor can make toward saving his men from injury is to inform them about the support plan and require them to observe it.

Dangerous and sometimes difficult-to-detect conditions of roof constitute another major factor in the occurrence of roof fall accidents. Often deadly are roofs of weak or fragile slate, shale, and greenstone—especially when they contain slips, mud seams, "kettle bottoms," and other irregularities. Slips, particularly, figure in fatal accidents.

Support in the center third of the roof is vital. This is the area of greatest stress. About one-half of all loose top drops from the center third of the roof. Furthermore, a large percentage of other roof falls extend from either side of the center into the center. Slips, mud seams, and similar irregularities add to the danger because they often run lengthwise of an entry or roof. Also, when places are driven too wide, the increase in center stress makes the likelihood of a fall greater.

Promptly replacing support knocked out by machines or by blasting is another major essential for safety. Proof of this lies in the fact that failure to replace temporary support is the cause of many roof fall deaths. Every miner should realize the importance of this reality!

Where roof bolting is used, the only sure way to avoid injuries and deaths is to strictly follow the practice of setting jacks for temporary support. Accident records reveal that a supervisor just can't be particular enough about requiring the use of temporary support—and enough of it.

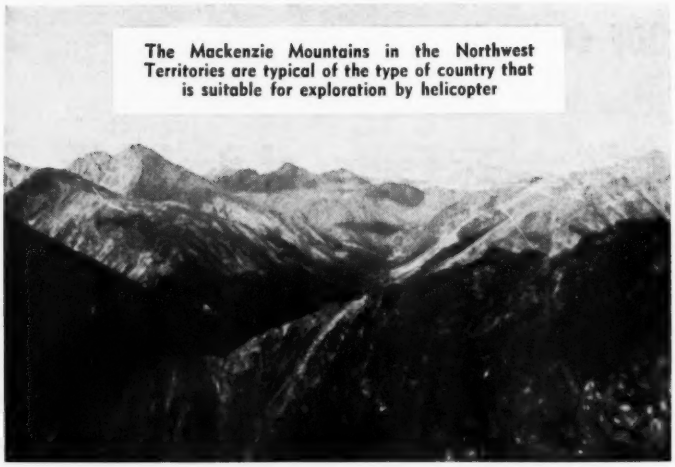
A sorry fact is that "common sense" safe practices often have been ignored when unsafe conditions were encountered. For example, safety posts or jacks were not set in the right place to offset the hazard of a slip, or posts were used instead of cross-bars or half-headers. Often the supervisor himself knew about the unsafe condition or practice, but did not give necessary instructions or, if he did, did not see to it that his orders were carried out. Such supervisors have seen their own men killed before their eyes.

In many instances, failure to act promptly to correct unsafe conditions is due to misjudging the degree of danger. For example, testing by sight, touch, and by "sounding" may reveal a hazardous roof, but the roof is judged "safe enough" to hold until a few more cars are loaded out or some other short task is done. Such guesses have proved right many times—but eventually they have proved wrong! A miner just cannot afford to take chances. The fatal mistake is that, while our eyes, ears, and finger tips can tell us whether the roof may be loose, they cannot tell us *how long* the roof will hold.

Miners and supervisors often are lulled into a false sense of security because no one has been injured by a roof fall for a long time. Months, and even years pass without a roof fall injury, even under dangerous top. The unsafe practices we have have been talking about in this sheet become more frequent, and then—someone is killed.

Let's do what we know should be done every day!

* Prepared by the Advisory Committee 1960 National Campaign to Prevent Injuries from Roof Falls in Coal Mines.



The Mackenzie Mountains in the Northwest Territories are typical of the type of country that is suitable for exploration by helicopter

HOW A SMALL MINING COMPANY CAN PURSUE MINERAL EXPLORATION

Formation of a syndicate allows broader participation and increases the chances of finding a valuable deposit

By KARL J. SPRINGER
President
Leitch Gold Mines Ltd.

MINERAL exploration is one of the oldest occupations of mankind. Primitive man searched for minerals and rocks to make his tools and weapons, and to adorn himself. As civilization advanced, man passed from the Stone Age through the Bronze Age and Iron Age into what might be called the "Age of Metals."

Progress in Exploration Methods

Through the ages, the methods of mineral exploration have changed—from the primitive to the highly technical approach of today. In former times, prospecting was carried out by visual inspection of outcrops followed by panning, trenching, tunneling, and sinking pits. The main tools used were the pick and shovel, blacksmith's outfit, hammer and steel, and gold pan; which tools of course, are still in use today in prospecting.

In recent years, scientific developments and inventions have greatly aided the search for minerals. These include recent developments in the sciences of geology, paleontology, petrography and mineralogy and in geological mapping. Development of the airplane, which came into use for mining exploration in the late 1920's, greatly stepped up the tempo of operations. Aerial photography has become an important tool in mapping, locating outcrops and interpreting geology, especially the structure of the rocks as to folding, faulting, shearing, etc.

The modern diamond drill has facilitated the work in determining the limits and values of mineral deposits.

The development of geophysical aids has accelerated the finding of ore bodies in recent years. These are particularly helpful in Canada where about 80 percent of the potential mineral areas are covered with overburden.

The Geological Survey of Canada has a program in progress of mapping the entire country by aerial magnetometer. Some of the Canadian Provinces have made aerial electromagnetic surveys for the benefit of mining exploration.

Geophysical surveys started about the last half of the 19th century when the dip needle or magnetometer was used for outlining iron ore bodies, particularly those of the Mesabi Range and the nickel ore bodies of Sudbury Basin. Later this extended to the search for base metals associated with magnetite or magnetic pyrrhotite.

The first serious use of electrical geophysical methods depending upon the conductivity of sulphide ore bodies to help in their location was probably in the late 1920's. The first success that the writer knows of was when Dr. Hans Lundberg found lead-zinc ore at the Buchans mine in Newfoundland in 1927. These methods were also used extensively in the Noranda, Quebec, area during that time.

Aerial Surveys—Fast, Economical

The greatest revolution in the search for sulphide or magnetic ore bodies by geophysical methods came in 1954 when electromagnetic instruments and the magnetometer were adapted for use in the airplane and later in the helicopter. Airborne instruments are able to cover large areas and to pick up conductive sulphide ore bodies under heavy overburden where they could not be located by the prospector.

An area can be surveyed aerially for ten percent of the cost and in less than one percent of the time that it could be done by ground geophysical surveys. An example of this is the area surveyed in northwestern Quebec by the Mattagami syndicate, which was organized by the author. An area of 600 sq miles was surveyed

by airborne geophysical instruments. Flight lines were spaced ¼ mile apart for a total of 2400 line miles. A Canso amphibious plane was used equipped with an electromagnetic instrument, a magnetometer, and a scintillometer. The survey was completed in five days at a cost of approximately $40,000. To have done this job by a ground survey would have taken about three years and cost at least $500,000.

Any anomalies recorded in an aerial geophysical survey requires checking by a ground geophysical survey to pinpoint them for further investigation.

The Mattagami syndicate survey located 237 electromagnetic anomalies and several very strong magnetic anomalies, which represented iron formations, besides numerous weaker magnetic fields. The most interesting anomalies were checked by ground survey and the important ones were staked.

The best looking anomaly was diamond drilled first. After penetrating about 50 ft of clay, a massive sulphide ore body containing zinc and copper was entered, thus again vindicating this method of exploration.



Preparing to move a prospecting crew to a new location by helicopter. Ground crews such as this pinpoint anomalies recorded in an aerial survey

Application of Geophysical Methods

Many sulphide ore bodies and some large iron ore deposits have been located in Canada in recent years by airborne geophysical surveys. Perhaps the most important are the large, comparatively high-grade nickel deposits in Manitoba discovered by the International Nickel Co. International Nickel was among the first to work on the adaptation of both the magnetometer and electromagnetic instruments for use in an airplane. They were one of the first to locate a sulphide ore body from an airplane equipped with an electromagnetic instrument. This was in the Province of New Brunswick.

Unfortunately, aerial geophysics have not yet proved efficient in mountainous terrain. This will be overcome as new instruments are developed to give greater depth penetration.

Geophysical instruments are of no help in locating non-conductive, non-magnetic or non-radioactive minerals unless they are associated with sulphides, magnetite or radioactive minerals.

Planning an Exploration Program

Planning a mineral exploration program and the attendant financing depends on the scope of the operation. This can run from the financing of a single prospecting party with comparatively inexpensive equipment and costing from $3000 to $5000, to a larger program costing $500,000 or more for a year's operation.

In speaking of a general exploration program, we are considering exploration over areas that, while not virgin, are for a large part unprospected for various reasons, and distinct from mine development or development of established mining properties in proven areas.

The writer's experience has been that an exploration program cannot be very effective without spending a minimum of $75,000 a year, and preferably a larger amount up to $500,000 or more. The latter figure would allow for participation in several operation units, thereby increasing the chances for success.

An operating exploration unit should be based as near the center of the area to be explored as possible.

When carrying out a prospecting program in mountainous country, where airborne geophysical instruments are ineffective, the unit would require the use of a helicopter for general reconnaissance, mapping, and moving men and supplies. This would need support by a fixed-wing aircraft, or a truck, if there is access to the area by road, to transport supplies and personnel to the area.

The crew at the base camp should consist of a manager, who should be a well-qualified geologist and geophysicist, an assistant geologist, four to six 2-man prospecting parties, and a cook. The assistant geologist prepares and keeps up geological maps as the work progresses and assists in servicing and placing parties as well as in examining prospects when necessary. Either the manager or his assistant should be capable of making soil and water tests and of doing mineral determinations.

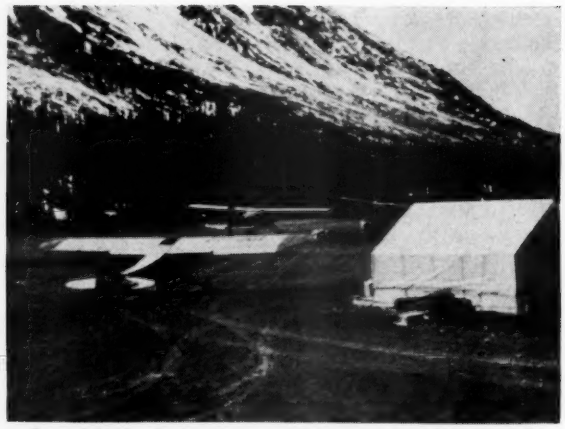
Equipment at the base camp should include a magnetometer and electromagnetic equipment to survey any mineralized area discovered, and equipment for testing soil and water samples. The prospectors should carry, in addition to their regular sampling equipment and prospector's tools, a mineral lamp, geiger counter and a gold pan for collecting concentrates for testing purposes. The parties should be visited every three to five days to bring them supplies and to pick up any samples, specimens or sketches. Such a unit would cost about $100,000 for a six-months' season in Canada. The Mackenzie syndicate, also organized by the writer and with a unit as described above, has operated for three years in the Mackenzie Mountains on the border of the Yukon and Northwest Territories. These operations resulted in the discovery of a rich tungsten deposit and some base metal prospects.

Cost of Aerial Survey Follow-Up

An airborne geophysical program, which is most efficient in the flat peneplained pre-Cambrian area of Canada, requires an airplane or helicopter carrying a magnetometer, electromagnetic equipment and often a scintillometer. Such equipment with operating crew is usually hired on a contract basis from a geophysical survey company at approximately $15.00 per line mile for fixed-wing aircraft to $25.00 per line mile for helicopter. A well qualified geophysicist should be on the job to plot the recording tapes as



Drill exploration camp of Canada Tungsten Mining Corp., Ltd., at Flat River, Northwest Territories



Several kinds of aircraft are used to support exploration and development crews in remote locations

they come in. Any promising anomalies recorded are checked by ground geophysical surveys to accurately locate them. This is followed by staking of claims to cover all important looking anomalies, after which they are investigated by diamond drilling or other means to determine the reason for them.

A rule of thumb is that the follow-up work costs about four times the aerial survey, therefore, if the original aerial survey cost $40,000, the over-all cost of the operation would be in the neighborhood of $200,000.

Financing by the Syndicate Method

How can a small company, that can only afford to spend from $50,000 to $100,000 a year out of their revenues on exploration, carry on such an expensive program?

The writer is interested in two such mining companies. We decided that to engage in such a highly competitive and speculative business, which normally only mining companies having very large incomes are able to afford, it would be necessary for a number of smaller companies to unite in a partnership. In this way, they could afford to take advantage of the expensive modern methods of exploration and also be able to enter into several ventures at the same time, thereby increasing their chances of finding a mine.

The next problem is the method of organizing a partnership, which we will call a "syndicate," to carry on the exploration venture.

First, it is decided how many partners there will be. A group of not more than six makes for an easily manageable partnership and has worked out well in our case.

Next, the maximum amount of money to be spent would be agreed upon. This naturally will be determined by the magnitude of the operation. There need not be any corporate form, but a trustee would be appointed by the partners to control all funds, accounting records and property.

Each partner is required to designate a person to represent it at all syndicate meetings. This person will have full authority to act for his principal in all matters pertaining to the operations.

The partners would appoint the trustee and the manager for the operations.

Each company is entitled under Canadian Corporation Income Tax Laws to write off their participation in the syndicate as an expense.

Another problem is that all partners may not see eye-to-eye as to the value of any prospect and the amount of money that should be spent upon it. Therefore, one or more of the partners may not want to spend any further money on a property while one or more may want to go on. There then arises the question as to what recompense those partners that drop out should receive.

We worked out an agreement with our partners that has worked very satisfactorily, and which we have used in about a dozen different exploration syndicates since 1957. We have been able to spread our "bets" widely and, as mentioned before, have had two successes so far.

Program Carried Out in Four Stages

In regard to aerial geophysical surveys, the development work would be conducted in four stages, as follows:

Stage #1—Funds would be provided for the aerial survey.

Stage #2—Following completion of the aerial survey, the partners would decide what funds are required to investigate, by ground geophysical survey, any anomalies located by the aerial survey and stake those thought important enough.

Any partner who did not wish to follow into this stage would forfeit all his interest in the syndicate, which interest would be divided among the continuing parties.

Stage #3—Upon completion of Stage #2, if it was decided by any one or all of the partners that further work was warranted, funds would need to be provided. If any of the parties did not wish to continue, they would be called discontinuing parties, and they would have no further rights, unless a company should be formed on a property. They would receive an interest in the vendor shares paid for the property in the proportion that the money they subscribed bore to the total amount of money subscribed by all the parties up to the time of the formation of the company.

Stage #4—Upon completion of Stage #3, if the continuing parties decided further work was warranted on any one of the properties, a company would be formed to take over the property. Further financing would be provided by the sale of the company's treasury shares. The partners would receive vendor shares for their interest in the property in proportion to the money they subscribed. Only the continuing parties would have the right to subscribe to further treasury shares in the proportion that their vendor shares have to the total vendor shares of the continuing parties.

No doubt the syndicate method will not fit all cases, but a number of smaller companies in Canada are following this practice. It allows them to participate in one or several exploration syndicates and this increases the chances of acquiring an interest in a valuable mineral deposit. Some mining companies with large incomes and working capital are also following this practice.

As indicated herein, mining exploration is becoming a highly scientific and expensive operation requiring considerable organization, well qualified technical personnel and expensive equipment. It is hoped that this brief may suggest to other small companies one way in which to participate in prospecting for minerals.

A Practical Look at Progress in Roof Control

Roof control begins at the face and never ceases to be one of the most important considerations in mining

By A. V. GIBSON
Division Superintendent
New River & Pocahontas
Consolidated Coal Co.

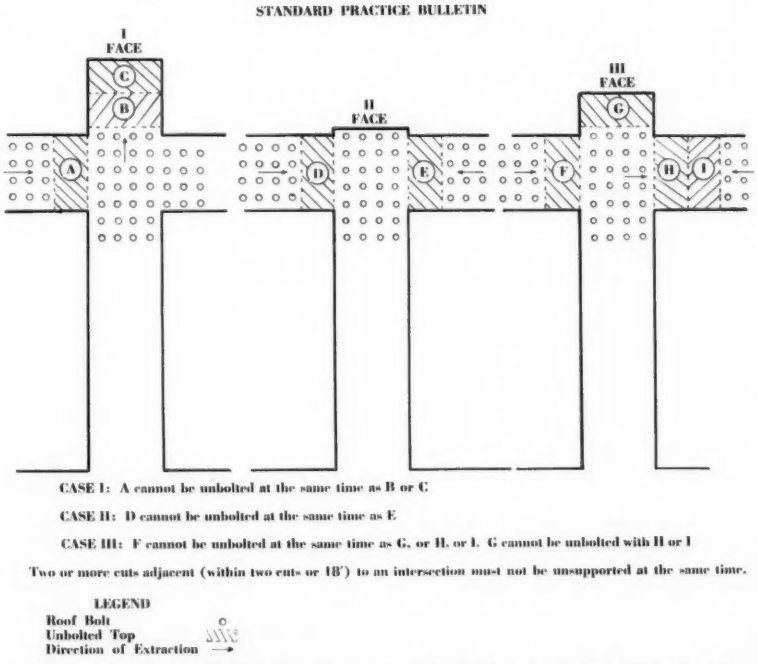


Fig. 1. Plagued with falling intersections, New River & Pocahontas Consolidated Coal Co. undertook a bolt checking program to determine what happened to the roof after it stood for a while. It was found that leaving top unbolted too long, or having too large an area unbolted, resulted in falls—if not immediately, some hours or days later. Consequently, foremen were instructed not to cut two adjacent places at intersections at one time. In the above diagram, the lettered, crosshatched areas designate cuts of coal. In Case I, the cutting of cuts A and B, or even A and C, at the same time is forbidden because the roof over these two cuts would be unsupported at the same time. Cases II and III are further illustrations of the combination of cuts which are not worked at the same time

WHEN men, in their various pursuits or enterprises, encounter natural forces that cannot always be predicted or controlled, they assign to these forces certain human attributes or characteristics. Thus, you may have heard or read, that roof in a coal mine is no respecter of persons, whether it be a timberman, foreman, apprentice or "old timer". Recent records show that the average experience of men killed by a fall of roof is 22 years. The records also show that over 90 percent of roof fall accidents are the result of human failure. It must be apparent that this lack of mutual respect is the cause of much grief. Those of us who are dependent on the safe and profitable mining of coal underground should have learned early in our experience to have a healthy respect for unsupported roof.

Mine management has moral and legal obligations to provide employes with the means to protect themselves. Legally it must provide a plan and the necessary materials to comply with it. Morally management must do everything it can to prevent injuries and loss of life which includes the task of getting people to use that which is available and to use it at the proper time.

First Consideration—To Protect Men and Equipment

To determine whether industry has made progress in any of these phases, we must know what the objective is, and then see if the industry is closer to the objective now than when it began.

The first big consideration in roof control is to protect men and equipment from failures and falls of roof while mining coal. There is a great amount of effort exerted by people associated with the industry to outline the different aspects and motives of this problem of education. These are:

(1) The preservation of human life. Management is concerned with protecting human life. The roof fall campaign of 1957–58 resulted in a 24 percent reduction of roof-fall accidents for all mines enrolled. They are currently participating in another roof fall campaign working for a greater reduction.

(2) Direct compensation costs. If there is one cost in which companies cannot hope for reduction, it is the cost per accident covered by compensation. Their ambition and resolve is to lower compensation costs by reducing the frequency and severity of accidents.

(3) Indirect costs of accidents and injuries. These costs are in addition to direct compensation costs per unit of production. Time is necessarily lost to take care of injuries. The effect on morale in general and the working attitude at the face in particular results in a material loss. Serious accidents may result in legal restrictions being conceived and imposed, not for their intrinsic value to mining but by the urgent compulsion to do something to prevent a recurrence of the accident. Costs in the case of injuries do not end here. For although the job of rehabilitating and retraining must be faced by the victim, the company has lost a trained and experienced employe.

(4) Long range and long term effect on the industry. Safety, or lack of it, affects home life and influences friends of the victim. It affects community spirit. It has an affect on labor relations, public relations, insurance rates and compensation laws. The writer could elaborate on any one of these specific relationships but industry knows at this point those are sound reasons for protecting men from mining accidents, the majority of which are the result of failing to control the mine roof.

Reasons why industry is more concerned now, than ever before, with protecting equipment from falls of roof adds up to costs—the cost to dig a machine out of a fall, the cost to repair and put it in shape, and the cost of materials for the whole operation. There is also the effect on costs of having the machine out of production or of providing and maintaining a spare for such emergencies.

The second largest consideration is to provide protection for openings other than the faces that are necessary for efficient production, haulage, ventilation, drainage and such services that support mining. This poses the question of time for certain areas have a life expectancy of a few months while other areas are needed for several years. Failure to provide sufficient support initially will result in costly work in replacing part, or all, of the support prematurely.

A third consideration is a material handling problem. In mechanical mining New River & Pocahontas Consolidated Coal Co. usually has to handle at least a part of the rock from an unwanted fall and this adds to the cost of mining. Perhaps the company can load it out of the way and "gob" it close-by. If the rock must be hauled out of the mine so as not to be in the way during retreat operations, it costs even more. These factors must be

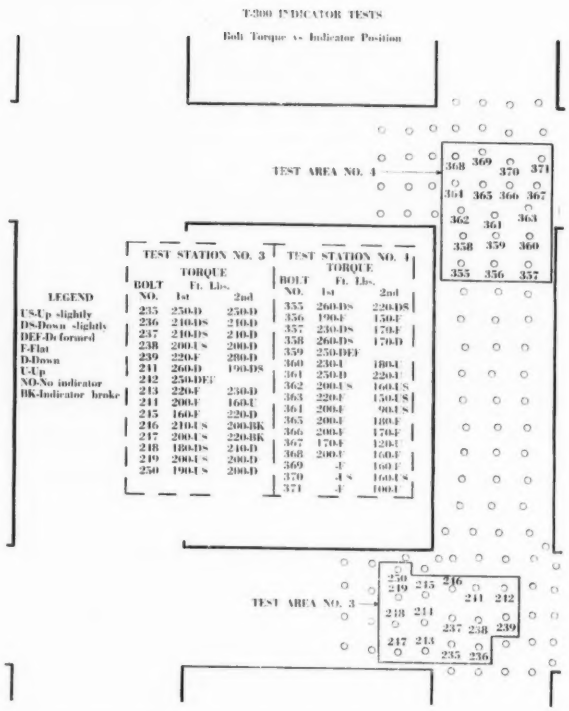


Fig. 2. Trained personnel were assigned to checking bolts at the time of installation and at specified periods after installation. This information was recorded on a map form as to location and torque. These data were also compiled into tables for study as shown in table I

Table I

FIRST INSPECTION—POST INSTALLATION

BOLTS—LOSS IN TORQUE			BOLTS—GAIN IN TORQUE		
Number of Bolts	Percent of Total Bolts	Loss—In Percent of Initial Torque	Number of Bolts	Percent of Total Bolts	Gain—In Percent of Initial Torque
71	47.5%	51%–100%	5	3%	41%–Over 50%
45	30.5%	21%– 50%	14	10%	1%–40%
11	7.0%	1%– 20%	3	2%	0%
Sub-Total 127	85.0%		22	15%	
			+127	+85%	
		TOTALS	149 Bolts	100%	

SECOND INSPECTION—POST INSTALLATION

BOLTS—LOSS IN TORQUE			BOLTS—GAIN IN TORQUE		
Number of Bolts	Percent of Total Bolts	Loss—In Percent of Initial Torque	Number of Bolts	Percent of Total Bolts	Gain—In Percent of Initial Torque
11	7.5%	100%	0	0%	Over 20%
42	28.0%	21%–100%	20	14%	1%–20%
74	49.5%	1%– 20%	2	1%	0%
Sub-Total 127	85.0%		22	15%	
			+127	+85%	
		TOTALS	149 Bolts	100%	

NOTE 1: First inspection was made one week after installation and second inspection two weeks after installation.

NOTE 2: The results of the second inspection were compiled or grouped to show the number or bolts that lost all or 100 percent, more than 20 percent, and less than 20 percent. (See Loss-In Percent of Initial Torque.)

Table I. Relationship between torque and time. The first test shows that after one week 85 percent of all bolts lost some torque and 47 percent of all bolts had lost more than half the installed torque. In the second test, two weeks later, 85 percent still showed a loss from the installed torque but many bolts that had initially lost 50–100 percent of torque had regained part of their original tension

weighed carefully to determine how much can be afforded for roof control in unattended areas.

Fortunately, most roof failures do not result in injury or loss of life. However, they do usually add to the cost of mining.

Roof Control Versus Roof Support

At this point, it would be well to make a distinction between roof control and roof support. To support is to hold up; to bear weight or stress. To control is to regulate within limits or to exercise a directing and guiding power. There are situations which emphasize control rather than support but this discussion will deal mainly with the latter, by far the most important aspect of roof control.

Mining, believed to have first started in open pits, eventually had to go underground. Support by means of large pillars gave way to back filling with waste and pack walls for protection. Timber came into use and eventually was supplemented with iron and steel props which, incidentally are mentioned in English mining literature as early as the 1850's.

Timber became the mainstay of roof support. Eventually perservatives were used to prolong the life of timbers. Experiments, scientific and empirical, determined the best species and size of timber to use. Variations in arrangement, known as sets, varied strength of support and also cost. Realizing timber treated with a preservative would eventually have to be replaced, the industry put other methods and materials into use. For greater support, engineers turned to masonry linings of brick or rock and of course reinforced concrete.

Usually between the portal and the faces, there is a transition of roof control methods. The methods would be indicative of the degree to which roof control was needed and could be afforded in each area.

At portals and over the main haulways, masonry columns with large steel beams or rails as headers were used to provide for strong support and long life. With these headers lagging and cribbing was often used to prevent arching of the roof. Today more steel liner plate is being used on concrete foot walls, especially in slopes. One newer method of permanent support is to bolt areas near the portal and to gunnite over the bolts and rock thus preventing the effect of weathering. Gunnite and grouting have been used for many years, and are popular as a sealing method where this is an important factor. Some support strength is offered by these methods. More recently sealing top with substances other than concrete is the practice. Sealing has helped alleviate the destruction of support through weathering at portals and on main intakes.

Due to costs of intallation the methods of roof control used for permanent control around portals or shaft bottoms cannot be used very far into the mine although permanence is still a desire. Timbering along haulways may merely mean setting large props with cap pieces, or larger sawed timber with caps or crossbars. It can be timber used in conjunction with roof-bolted headers or just roof bolts with bearing plates.

In the face area whatever method of timbering is used, its purpose is to provide safety while work is going on. It may be either permanent or temporary support to be replaced with permanent support after the loading machine or continuous mining machine has left the place. Posts may be a standard plan with crossbars added as needed when breaks in the roof or anomalies are encountered. Leaving top coal where height permits is another means to control roof both by its effect in sealing and supporting. Taking draw rock down and scaling are other methods used to effect roof control.

Roof Bolting—A Radical Departure from Conventional Timbering

Many mines, however, had tried almost all methods normally in practice and found there was much to be desired. As labor and supply costs mounted, taking down rock that could not be held with conventional timbering was becoming prohibitive. Several mines had top that could not be supported economically. It was no rare occurrence for hand-loaders to spend half a shift to remove sagging timber, clean up the fallen rock and retimber before a car of coal could be loaded at the face. It became apparent to the management of many mines such as this, that conventional methods did not provide the answer to the problem of high cost mining.

Fortunately, while many coal mine operators were unaware of it, a radical departure from conventional timbering was undertaken in the hard rock mining industry. This is the technique of locking the rock in position by use of bolts. The basic principle of using bolts to lock thin roof strata together to form a thicker beam of greater strength is not new. Even the principle of using suspension roof support is not new for it was used in this country as early as 1905, and was in widespread use in the mines of St. Joseph Lead Co. for 20 years prior to the time the U. S. Bureau of Mines became interested in 1947.

Twenty-five years ago the writer had the privilege of working with a man who was responsible for applying roor bolting as early as 1917. J. C. Baldwin successfully installed roof bolts over the main haulway in the Sagamore mine of Pocahontas Fuel Co. These bolts were still intact when studied by the Bureau some 30 years later. The principle of roof bolting is not new but the wide acceptance and application has come mostly within the last ten years.

In years past, when the cost of roof support by conventional methods became excessive, portions of the mine were stopped and some mines were closed. Ten to 12 years ago this process of elimination was greatly accelerated. As machines replaced hand loaders, efficiency, therefore costs, were dependent on effect of roof. In the face roof bolting began to replace timbers, giving road clearance for mobile equipment.

Elimination of heavy crossbars yields overhead clearance. Safety posts interfering with work are largely eliminated except for those used by roof support crews. Fewer men are subjected to the consequence of accidental dislodgment of safety posts or jacks. Ventilation is improved, which is vital to rapid extraction of coal by mechanical loaders, and dust clean-up is facilitated by greater maneuverability. Handling of supplies, cable and hoses are made much easier where there is no close timbering as was necessary prior to roof bolting.

Much of the initial experimental work with bolts was done with one-in. split rod and wedge type bolts. Now, in many mines, the greater part of the mainline haulage is supported in this manner. One-in. bolts are bigger, stronger and more expensive but are justified over mainline haulage. Once it was proved successful, New River & Pocahontas did not wait at its properties until timber had to be replaced. Many thousands of feet of timber was taken out before its useful life was gone as benefits from bolted haulways were too great to do without any longer than reasonable progress warranted. In one of its mines, a haulway bolted ten years ago is still standing while timber would have been replaced about five times. Roof bolting is now found not only in the faces but all the way from the portal.

Trend Toward Use of Steel in All Phases of Roof Control

Concurrent with the wide use of

bolting, a trend toward the use of steel in all phases of roof control was noticed, especially in prefabricated steel. The use of liner plate and arch rings in areas for permanent support have replaced timber and masonry to a large extent. Steel plates which can be recovered are being used in the construction of overcasts, primarily a ventilating device but where roof support strength must be considered. In areas of permanent support, steel roof ties are used in some instances to replace much thicker wooden collars. The use of steel yielding roof jacks designed in Europe have been tried not only in experiments with the "coal plow" or similar machines but in conjunction with continuous and conventional units. The purpose in the latter cases was to enable the roof to reach equilibrium without falling.

After the initial roof bolting techniques and materials were developed sufficiently to prove the method, refinements attracted the attention of mine managers, Government agencies and manufacturers. Though it was proven that roof bolting solved the more general problem of support for some mines, the problem of roof failures remained. There was still the problem of matching roof support with loading rates to increase productivity. Dust from drills contaminated the coal and posed health hazards. Continuous miners continued to pose new problems after conventional systems were fairly well established in bolting methods.

The one-in. bolts were largely replaced with a lighter bolt of high strength steel. Expansion shells of many various designs were and still are being conceived and manufactured. Drill bits and steel are improved. There is a wide choice of roof drilling machines. Dust collection methods are improving. Today the management has only to ask to have engineering representatives at the mine ready to investigate roof bits, drilling machines, roof bolts and any accessories used in roof bolting.

Failures of Bolted Top

One good effect that bolting has had is to make more people conscious of roof behavior. New River & Pocahontas has had failures of bolted roof that have been very costly when considered from any standpoint. Roof bolting is the company's primary plan of support with timbers added on retreat or in areas with heavy stress. Failures of bolted top have occurred most frequently at intersections, but in certain areas the falls have extended across two or three intersections and the intervening top. In the crosscuts or breakthroughs, roof falls interfere with haulage and movement of the equipment and in entries or headings ventilation is interrupted.

The company mines in several seams but the greater part of its experience with bolts has been in the Pocahontas No. 3 seam which has a draw rock varying from 6 to 24 in. Over the draw rock is a three-in. seam of coal and above this for several feet is a laminated slate interlaced with streaks of coal ⅛ to ¼ in. in thickness. There is little strength to the top and the success in holding it with bolts depends on the strength of the beam formed. However, this bolted top often fails. Plagued with roof falls at intersections, management undertook a program of checking the bolts to determine what happened to the roof after it stood for several hours or days. It began to analyze its trouble by investigating each fall and plotting these on a map.

It was found that leaving top unbolted for too long a time, or having too large an area unbolted, resulted in falls—if not immediately, some hours or days later. Foremen were instructed not to cut two adjacent places at intersections at one time in order not to have excessive unbolted top swinging across corners of blocks. This has helped prevent some falls (see figure 1).

It was thought for a long time that if the company used a longer bolt it should have better success in binding the roof together. In this roof, however, there is no better roof strata at five ft than at four. Consequently, when an attempt was made to bolt the intersections with five-ft bolts, the falls were about as frequent but were a foot thicker.

Management concluded after two years of trial that five-ft bolts were no more beneficial than four-ft bolts. Had the longer bolts been anchoring in a stronger stratum than any strata below, the results may have been better, but such was not the case.

To keep intersections open out by the faces, the yielding steel jack was used which allowed for settling of the roof while giving strong support. These jacks were later recovered by replacing them with cribs. Eventually 12-in. posts were used instead of the jacks with cribs built around them after faces advanced. This method of supporting intersections added strength to the roof bolt plan but with mobile equipment they were subject to being knocked out too often. This situation is worse, when there is weight on the center posts, than the original problem, so it was discontinued. With a different complement of equipment than the company used the method may well have merit.

Management's next step was to assign trained personnel to checking the bolts at the time of installation and at specified periods after installation. The information was recorded on a map form as to location and torque as shown in figure 2. Actually this diagram is part of a later program of the company where information relative to visual tension indicators was also recorded. However, the diagram shows how management chose specific tests areas and recorded information directly on a map projection. By marking the bearing plates for identification, bolts were tested periodically and a history of certain bolts was kept. It is then possible to identify bolt torque readings with their exact location in the roof. These data were also compiled into tables for study as shown in table I. This table shows bolt torque data as it was compiled from a chart such as figure 2. Test bolts were checked twice after the initial check made at installation.

In the first test it is seen that after one week 85 percent of all bolts lost some torque and 47 percent of all bolts lost more than half the installed torque.

In the second test, two weeks later, 85 percent still showed a loss from the installed torque but many bolts that had initially lost 50–100 percent had subsequently loaded. As a basis for study it was assumed that if bolts lost more than 20 percent of installed torque by the first inspection, the roof had slipped too much.

After studying the data management first tried having the bolts retightened to desired torque. This work was fitted into the cutting machine cycle. In each place the bolts from the previous cut were to be checked and tightened, if necessary, to the prescribed torque. This, of course, is doing work on the bolts twice when it is most desirable to have bolts set properly at the start and to support the roof without further attention. This retightening was a slow process and the company still had no positive proof it was preventing falls.

Tension Indicator Tests

In the latter part of 1957 the company participated with the manufacturer of a visual tension indicator and the U. S. Bureau of Mines in conducting an extensive test of the indicators. At the very beginning it was jointly decided that the bolts should be set at a higher torque. Close

checking on torque resulted in consultation with the supplier of hydraulic oil and the drill manufacturer. The result was that drill motors were modified to supply a more even torque as the temperature of the hydraulic oil changed with increased operating time. Several additional changes or modifications were made in the roof bolting procedure.

From the tension indicator tests, which were made on the section with the most troublesome roof, it was positively concluded that bolting is most successful when applied immediately after top is exposed. Second, and no less important, is the proper installation. Where the greatest amount of torque bleeding off was found, although bolts subsequently loaded up to, or above, installed torque, failures of roof resulted.

It was observed that when the draw rock is thinnest, six to nine-in. bolts have a greater tendency to bleed off due possibly to crushing out the three-in. seam of coal above it. Although this rock is taken over haulageways, it is economically impossible to handle it from all working places.

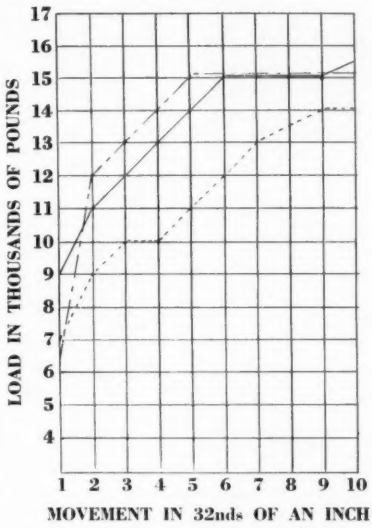
The company still uses tension indicators for spot checking although, of the several types on the market, none are entirely satisfactory under all conditions. It has acquired its own test equipment and has trained men on its use. The results of tests are compiled for reference (see figure 3). The bottom half of figure 3 records the actual test data of a particular expansion shell. The action of this shell was studied by making pull tests with it at different installed-torque levels. At the top of figure 3 is a graph of the same data. This shell, as do most shells, had a greater holding power the higher the installed torque (within limits).

Usually the shell currently in use is tested alongside the test shell so that a control sample is available. Company personnel and manufacturer's representatives usually conduct the tests. The company conducts much testing on its own and with the State and Federal inspectors. It is on constant alert for improvements and methods of making roof bolting more effective more of the time.

Adapting Roof Control to Continuous Mining

New River & Pocahontas has the problem, common to other mines, in providing roof support for both conventional and continuous mining units. Within the industry there is continuous progress being made in adapting roof control to continuous miner systems. "Satellite" bolters, as well as self-contained units, are satisfactory for some but not yet for all mines. Remote control of miners will be an important aspect of the attempt to thwart the effect of unpredictable roof action. One aspect of roof control in which the company is interested is the detrimental effect of shooting coal. It has good reason to think continuous mining will aid roof control by eliminating shooting of coal.

The company is aware of the progress being made in the study of mountain bumps, which take on the broader meaning of roof control. Its neighbors have had to devote considerable study to this phase of control. If the company encounters this problem it will have gained by the work others are doing on it now.



There are studies of roof action being made by the use of instrumentation such as strain gauges, convergence gauges and sonar devices. Lately the cementation of roof has appeared as a possible means to better roof support and control. An experiment with this has been scheduled in one of the company's mines.

To the individual, the amount of progress may well be dependent upon the magnitude of the problem with which he started. Roof control techniques recently developed are known to be big factors in operating certain properties today. Industry cannot look forward to better natural roof conditions.

Since the industry is not able to effect 100 percent roof control now, it knows it has got to encourage and participate in efforts and experiments to develop new methods if it hopes to operate in the future. The mining industry cannot be satisfied with present productivity where improved methods of roof control can help increase it.

Successful roof control must begin as soon as the coal is removed. Roof control begins at the face and never ceases to be one of the most important considerations in mining. But, each man must know enough to use what is available to protect himself and his machine. He must know and believe he is responsible for his fellow worker. The operator is obligated to establish a plan of roof control and furnish materials needed to comply. However, the industry cannot stop here. As long as men are robbed of life or limb through roof fall accidents, industry has not progressed enough.

Jack Adams
T. E. Musick (NR & P)

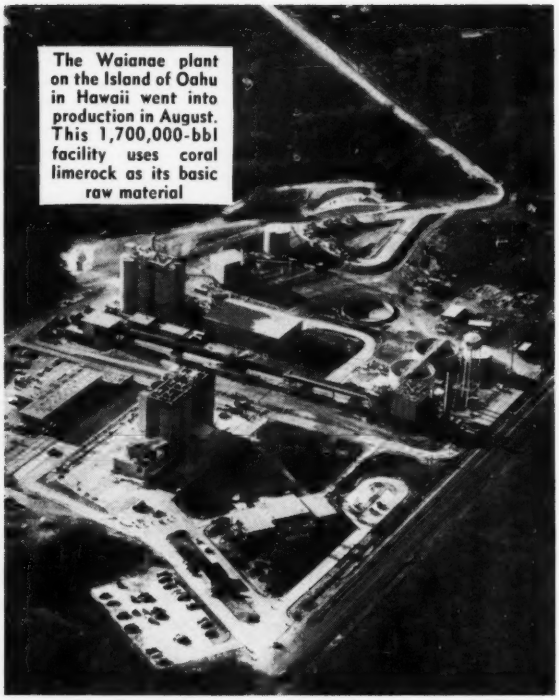
Mine No. 11 Section 4 Main East Date 1-12-60 Inspector G. W. Gibson (NR & P)

Bolt: 5/8 by 48 in. 1040 Steel						Load Expressed in Thousands of Pounds Movement in Fractions of an Inch										
Shell No.	Code	Hole Dia.	Torque (ft lb)	Bolt Stretch (in.)	Anchor Movement (in.)	1/32	2/32	3/32	4/32	5/32	6/32	7/32	8/32	9/32	10/32	Total Movement* (in.)
1	———	1⅜ in. Bit	190	3/16	5/16	9	11	12	13	14	15	15	15	15	15.5	8/16
2	- - - - -	"	140	2/16	6/16	7	9	10	10	11	12	13	13.5	14	14	8/16
3	— · —	"	210	1/16	7/16	6.5	12	13	14	15	15	15	15	15	15	8/16

REMARKS: These tests were run in No. 4 entry 80 ft outby the immediate face. Six in. of top was brushed.

** Total Movement includes bolt stretch and anchor movement.*

Fig. 3. New River & Pocahontas has acquired its own roof bolt test equipment and has trained men in its use. The results of tests are compiled for reference. In the above example, the bottom half records the actual test data of a particular expansion shell. The action of this shell was studied by making pull tests with it at different installed-torque levels. At the top is a graph of the same data



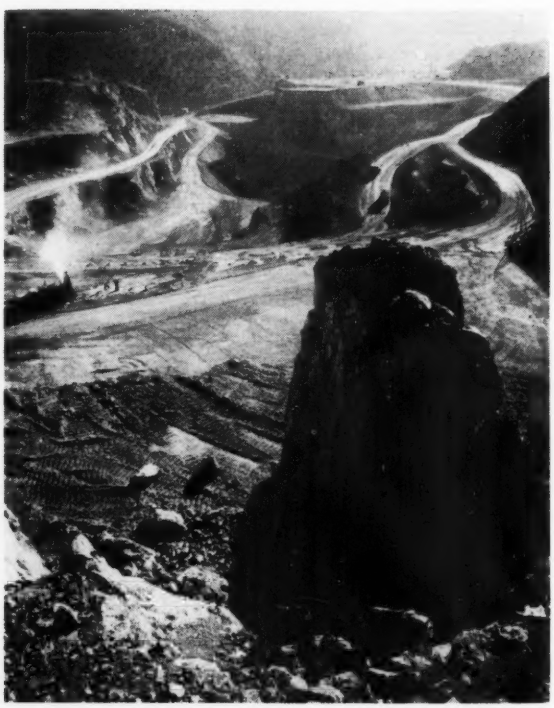
The Waianae plant on the Island of Oahu in Hawaii went into production in August. This 1,700,000-bbl facility uses coral limerock as its basic raw material

CEMENT RAW MATERIALS

Variety in Mining

Deposits ranging from easily mined coral to geologically complex limestone present a wide variety of problems

By E. B. CONNERS
Mine Engineer
Permanente Cement Co.



About 2,000,000 tons of cement rock and 2,800,000 tons of waste rock are produced annually at the Permanente, Calif., quarry which provides limestone for the largest cement plant in the Western United States

PERMANENTE Cement Co. is currently mining and processing the major portion of raw materials for each of its four cement plants. The original and largest plant is located in the foothills of the Coast Range about 40 miles south of San Francisco. Another, the Cushenbury plant, is in the Mojave Desert about 30 miles east of Victorville on the edge of the San Bernardino Mountains. A third is at Bellingham, Wash., on the shore of Puget Sound near the Canadian border, and a fourth is on the west shore of Oahu Island in Hawaii. Thus, the company has a wide geographic distribution of operations and a wide variety of climatic conditions affecting its mining operations.

The Permanente plant operation enjoys the very moderate coastal climate of the San Francisco Bay area with warm days and cool nights. The summer high temperature reaches into the nineties, and there is occasional frost in the winter. A rainy period in the winter is the only adverse weather condition, but it has little effect on the mining operations.

At the Cushenbury plant, the summers are hot and dry, and temperatures commonly reach 110°. In winter, the days are ordinarily pleasant, but freezing does occur at night and equipment must therefore be protected from it. Occasional rain and snow is not sufficient to materially affect mining operations.

The Hawaii operation enjoys the best of the idealistic climate that the state is noted for. Located on the west side of Oahu in a semi-arid area, this plant has the benefit of the continuous year-around mild temperature, yet avoids the rain common to most of the rest of the Island.

The Washington mining operation is located in the mountains about 25 miles east of Puget Sound and misses the moderating influence of that body of water. The summers are pleasant with occasional rains, winters are difficult—rain, freezing rain, and heavy snows are the rule—and all equipment must be protected from freezing. The crushing plant must be heated and special attention given to heating the crushers to prevent wet and frozen material from choking them. Drainage of surface waters requires constant attention. Blading of snow from the haul roads and scarifying and/or sanding is necessary to obtain traction for the haulage trucks. Smaller and more frequent blasting is done in the winter to minimize the wetting and freezing of the muck piles.

Each plant presents its own distinctive problems other than those noted above. Let us examine each.

Permanente—Largest Cement Plant in West

Producing cement rock for the largest cement plant in the West encompasses the ever present grade control problem coupled with waste removal in a geologically complex deposit. Annual production is about 2,000,000 tons of cement rock. The stripping ratio varies from month to month depending upon demand and local coditions in stratigraphy.

The deposit consists of a high grade limestone, that contains plus 87 percent $CaCO_3$, overlain by a low grade limestone that averages about 67 percent $CaCO_3$. These formations have been badly folded and faulted and are now broken into fault blocks, each with varying dip, strike and elevation — the dip usually 30° or greater. A post-faulting intrusion of andesite occurs along faults and on bedding planes, usually within the low-grade limestone. Both the high grade and low grade limestone consist of an interbedding of relatively pure limestone with a pure chert, the difference being simply a matter of the relative proportion of limestone and chert. The andesite varies from a fresh dense rock to its final product of decomposition — clay. From this the company must produce, by selective mining and blending, an average grade of 82 percent $CaCO_3$ for the plant.



Selective mining is practiced at the Cushenbury quarry in producing metallurgical and cement grade limestone

The quarry is developed on 50-ft benches. The usual deployment of equipment is to have one shovel in straight waste, one in high grade, and one in low grade.

Stockpiles Promote Flexibility in Mining Operation

To facilitate this highly selective operation, there are two primary crushers at the quarry, each discharging into a separate stockpile over a stacker conveyor. One crusher and stockpile is used for high grade (plus 82 percent $CaCO_3$), and the other crusher and stockpile is used for low grade (minus 82 percent $CaCO_3$ and usually plus 70 percent $CaCO_3$). With this arrangement, haulage trucks can be dispatched from the shovel to either crusher or to the waste dumps. A shovel seldom works a three-way split, but a two-way split is a daily occurrence. Currently about 1.4 tons of low grade limestone and andesite is wasted per ton of cement rock produced.

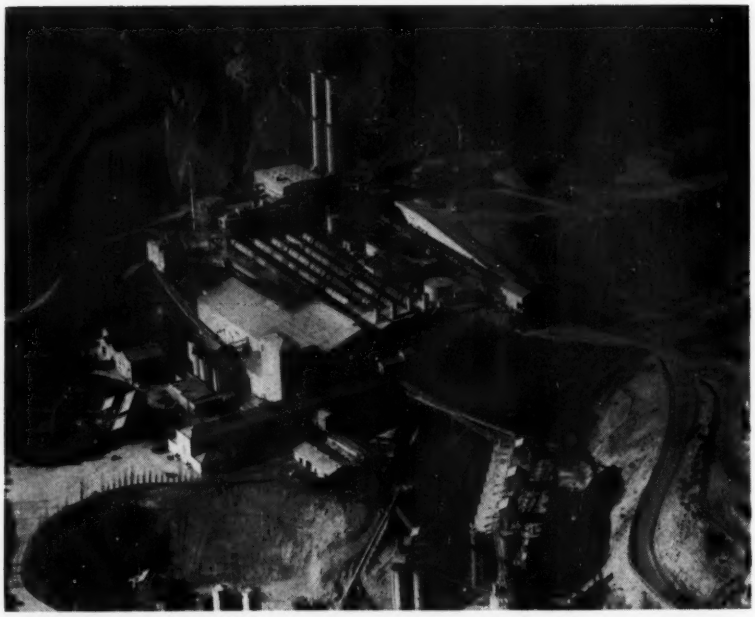
A system of stockpiles is a major factor in maintaining low unit costs by giving the mining operation flexibility. The primary stockpiles have a live storage capacity of 42,000 tons of high grade and 80,000 tons of low grade. Rock drawn from the primary stockpiles passes through the secondary crusher and is conveyed about one mile to the plant site, where it is discharged into one of three stockpiles having a combined capacity of 280,000 tons of live storage. Thus, the combined storage of 360,000 tons could conceivably keep the plant in operation for about two months of peak production with the quarry shut down.

The company has completed testing for the beneficiation of low grade limestone that it is currently wasting. In the near future, a flotation plant is planned to upgrade this material to feed grade. This is expected to reduce materials cost and extend the life of the deposit. The plant will be the third such installation in the United States and the first in the West.

Mine Two Products at Cushenbury

At Permanente's Cushenbury plant, the problem is to produce metallurgical grade limestone and cement grade limestone, with quite divergent and rigid specifications for each, by selective mining. The annual production is about 650,000 tons of cement rock and 350,000 tons of metallurgical grade limestone.

Limestone in this deposit is essentially a high grade limestone that has been subjected to folding and faulting. A zone of silicified limestone



Stockpiles at the 8,500,000-bbl Permanente plant have a combined storage capacity of about 360,000 tons. The stockpile system allows flexibility in the mining operation and is a major factor in maintaining low unit costs

about 50 ft wide and averaging around 32 percent SiO_2 strikes through the quarry area.

Limestone containing two percent silica or less is mined for flux rock, while that running in excess of two percent silica is mined as cement rock. By blending rock from the silicified zone, an attempt is made to keep the grade of the cement rock in the low eighties in percent $CaCO_3$.

Each truck load leaving the shovel is dispatched to the primary crusher, where the crusher operator can direct the rock, as appropriate, to either the cement rock or flux rock stockpile by simply flipping a switch. The cement rock primary stockpile has about 10,000 tons of live storage capacity, and the flux rock primary stockpile has about 14,000 tons live storage capacity. Both of these are augmented by secondary stockpiles of 7500-ton capacity each. Even though these stockpiles are small compared to those at Permanente, they do give the quarry and crushing plant the desired degree of latitude for efficient planning of work.

Minus ¾-in. material screened from the flux rock in the secondary crushing plant becomes the high grade limestone used to blend with the lower grade cement rock which is mined as such. Thus a high grade and low grade stockpile of cement rock is maintained to furnish any desired blend to the mill.

Clay is mined from a deposit about two miles from the plant. This is a simple but efficient operation. The clay is ripped and dozed into convenient piles from which a tractor loader loads it into quarry trucks that haul it to the plant. It is passed through a small crusher and goes directly into the mill feed bin.

Other raw materials, namely, high grade silica and iron ore, are brought in from outside to effect refined control in the blending of raw materials.

Washington Operation Acquired in 1958

The problem here is grade control complicated with growing pains. Production is about 500,000 tons of cement rock per year.

The limestone quarry is located near Sumas, about 30 miles northeast of the plant. The deposit outcrops near the top of a mountain at an elevation of 1660 ft. It strikes north-northeast with the strike of the mountain and dips about 45° to the east. In certain areas, the rock is hard, amorphous and silicious. Localized areas of high magnesia have been noted, and occasional lenses of shale occur.

This quarry and cement plant was acquired as an operating unit in 1958 from Olympic Portland Cement Co. At that time the quarry was operated on a single bench at the level of the crushing plant. The quarry face was up to 240 ft in vertical height, and blast holes were drilled to the level of the quarry floor by churn drill. Blasting produced very poor fragmentation due to the nature of the rock, excessive burden per hole and erratic hole spacing. Secondary drilling costs were extremely high.

The crushing plant was limited to about 200 tph. This was the capacity of the aerial tramway that carried the crushed rock approximately 1700 ft horizontally while dropping about 1000 ft vertically from the crushing plant to the railroad bin. The tram was a "bottleneck" that reflected in low capacity and high unit cost.

To rectify the conditions noted, a mining plan to bench the quarry in 40-ft lifts was developed. The churn drill has been replaced with a rotary machine which is giving satisfactory performance. Footage per drill bit is low—about 800—but experimentation is continuing to find means of improving this.

Haulage "Bottleneck" Eliminated

Closer spacing of drill holes, more attention to rock fractures, and microsecond delays in the blast series have contributed to improved fragmentation, but it is clearly a subject requiring continued study.

The aerial tram has been replaced by a gravity and belt conveyor system. Crushed rock is dropped 230 ft vertically through a 24-in. diam, cased borehole to a stone box. From the stone box, the rock flows onto a 36-in. conveyor belt in a 500-ft tunnel. The rock is conveyed to the tunnel portal and is discharged down the mountain slope a distance of about 1000 ft on a 45° incline into a stockpile. This stockpile is equipped with a reclaim tunnel and conveyor, which carries the rock into the railroad bin for shipping to the plant.

Clay is dug from a pit about four miles northwest of the plant. This clay is under water and is dug and loaded into railroad cars by a railroad crane equipped with an orange-peel bucket. It is handled wet all the way.

Hawaii Operation Mines Coral Deposit

The plant on Oahu Island recently started operation and while specific problems have not yet developed, dust control is expected to be of major concern. Dust control measures will include sprinkling and paving of haul roads.

Calcium carbonate, the main raw material, comes from an uplifted deposit of coral. An annual demand of about 500,000 tons of coral is expected, about half of which will be used as mineral aggregate for concrete and plaster. This deposit has a

maximum elevation of ten ft above sea level in two 25-ft benches.

The coral in general is soft and will not require drilling and blasting, though there are some hard ledges near the surface that may require breaking with a tractor and rooter. Loading is done with a 2½-yd shovel and haulage is accomplished with a 25-ton tractor-trailer unit that complies with State highway use laws. The coral is hauled from the quarry approximately two miles to the primary crusher at the plant site. All raw material storage is in concrete silos. The two silos for coral storage have a total capacity of about 4000 tons. Raw materials other than coral are at present acquired from others.

In general, thorough and accurate sampling of all raw materials is required at all plants to effect the high degree of control required to produce products meeting rigid specifications. Large stockpiles are invaluable to the operations enabling the mining operations to work efficiently with a minimum of changes from one rock grade to another and yet produce consistent products.

Plan Operation in Alaska

Two deposits of limestone have been discovered on the Kings River near the Matanuska Valley in Alaska. Other raw materials exist in the area. A plant site has been acquired at Sutton with frontage on the Alaska Railroad, the Glenn Highway and the Matanuska River. Coal mines in the vicinity of Sutton may furnish the fuel, although natural gas now available in Anchorage may be piped in at a competitive price.

Bulk cement will be moved by truck or railroad to existing bulk facilities in Anchorage and Fairbanks.

The climate of this portion of Alaska compares favorably with that of Minnesota, Wisconsin and Michigan. Open cut coal mines in the area pursue a year around operation with little concession to weather. Operators report two or three days lost per year due to weather. Permanente's plans call for open cut operation also.

The deposit area, the Kings River Valley, and the plant site have been photographed for aerial mapping. Detailed topographic maps of pertinent areas will be produced during the winter. Plant planning is underway.

Early in the spring a road will be built from the Glenn Highway into the deposits of limestone. This will be followed by field geology studies, exploratory drilling and other development work.

CANCER'S DANGER SIGNALS

CAN BE SAFETY SIGNALS

You can do **two things** to guard yourself against cancer: Have an annual health checkup. Alert yourself to the seven danger signals that could mean cancer:

1. Unusual bleeding or discharge. **2.** A lump or thickening in the breast or elsewhere. **3.** A sore that does not heal. **4.** Change in bowel or bladder habits. **5.** Hoarseness or cough. **6.** Indigestion or difficulty in swallowing. **7.** Change in a wart or mole.

If your signal lasts longer than two weeks, go to your physician. Give him the chance to give you the chance of a lifetime.

AMERICAN CANCER SOCIETY

MINING HUGE ORE BODIES IN SWEDEN

(*Continued from page 42*)

Smooth-surface blasting in shafts and drifts as well as in rock chambers is becoming increasingly important. Blasting of large rounds below ground is being practiced more and more, as in connection with long-hole drilling. There is a rapid development in the field of short delay blasting and the relevant control measures for locating defects and ensuring firing.

New Raise Climber Developed at Boliden

When developing small drifts, the face is ordinarily opened up by parallel-hole blasting, while in large drifts and tunnels cut blasting is still the most economic method.

A lot of attention has been given to raising. Long-hole drilling of raises up to 70 ft in length with hammer drills works well, but good results have been obtained in connection with diamond drilling of raises up to 170 ft. The Alimak raise climber is already known, and at Boliden a new climber has been developed. It is suspended from a rope and has its hoisting machinery fitted in the climber.

The mining methods have been developed into block caving and long-hole mining—methods which have effected labor economy and led to more concentrated working areas. In cut-and-fill mining, hydraulic filling has worked out favorably.

To reduce the amount of secondary blasting and make automatic loading, haulage and hoisting possible, a coarse crushing plant installed below ground is necessary.

In large drifts and tunnels, trackless haulage is frequently used. It has also been introduced in small drifts by the adoption of such equipment as pneumatic dumpers and shuttle cars.

Automation and remote operation of rock drills, hauling trucks and loaders are under development and will probably be extensively used in the future. The main level transports to existing shaft plants have in several cases been automated by means of CTC plants.

Today automatic skip hoisting is standard practice in new workings. By means of various signal devices and TV cameras, one man is able to operate and check a long series of operations. Developments in large mines will probably be towards haulage systems controlled by data processing machines.

Part II – THE DESIGN OF AMMONIUM NITRATE-FUEL BLASTING AGENTS

By GEORGE B. CLARK and R. F. BRUZEWSKI
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Based primarily on data obtained from an explosives research program at the University of Missouri, Part II considers the influence of moisture, oil content, bulk and prill density, particle size and inert coating on the sensitivity of ammonium nitrate-fuel blasting agents. The studies also reveal the effects of variations in mixing and hole-loading practices at the mine

The effect of water content upon sensitivity has received only a preliminary investigation. Tentative results indicate that moisture content of less than one percent has little or no effect on the sensitivity, and in previous tests[3] it was found that ten percent moisture was the upper limit at which detonation could be induced (see figure 4).

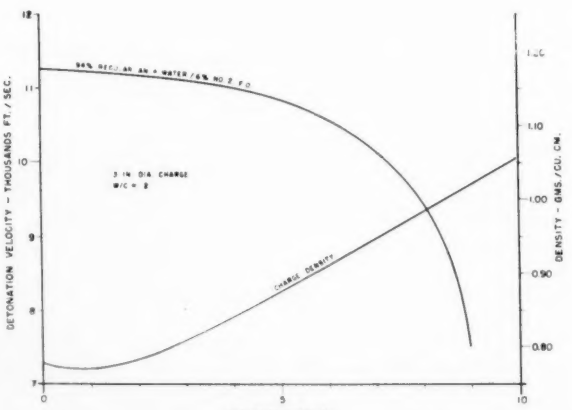
Since AN is highly hygroscopic and very soluble in water, the amount of moisture contained in an AN explosive mixture has a marked effect upon its performance. Varying percentages of water were added to fertilizer grade prills, and then the desired percentage of fuel oil, the whole being thoroughly mixed. The percent moisture was taken as the total moisture, determined on a mixed sample using the Karl Fischer titration method. The effect on detonation velocity is shown in figure 4. Above four percent water the detonation velocity decreases sharply and mixtures containing nine percent or more of water could not be detonated.

Considering the fact that the heat required to vaporize ten percent water by weight would be well over 50 kcal per kg of moist explosive compared to about 850 kcal available to support detonation, plus the necessary heat to bring the added moisture to detonation temperature, the explanation for detonation failure seems mostly attributable to these processes. As a parallel phenomenom in some cases it has been found possible to quench a detonation by adding as little as five percent finely divided sodium chloride to an explosive.

Influence of Oil Content on Sensitivity

The rapid growth in utilization of prilled AN-fuel oil mixtures for commercial blasting before its explosive properties had been completely defined, led to many conflicting claims of its properties. One particular point was the amount of fuel oil to add to AN prills to obtain the best blasting agent. Simple theoretical calculations show that a stoichiometric balanced mixture (94.4 AN/5.6 fuel oil) will have the greatest maximum available amount of energy, and consequently the largest available work potential. However, confusion has existed between the importance of sensitivity and that of detonation velocity. One

Fig. 4. Because AN is highly hygroscopic and very soluble in water, the amount of moisture contained in an AN explosive mixture has a marked effect upon its performance



INFLUENCE OF MOISTURE CONTENT UPON DETONATION VELOCITY

error has been the mistaken belief that the most sensitive mixture has the highest detonation velocity and is, therefore, the most desirable for blasting purposes. Under controlled test conditions the influence which oil content has on the sensitivity of regular fertilizer grade AN prills was determined. The results in figure 5 show that the sensitivity level remains essentially constant from one to seven percent fuel oil for the conditions of this sensitivity test.

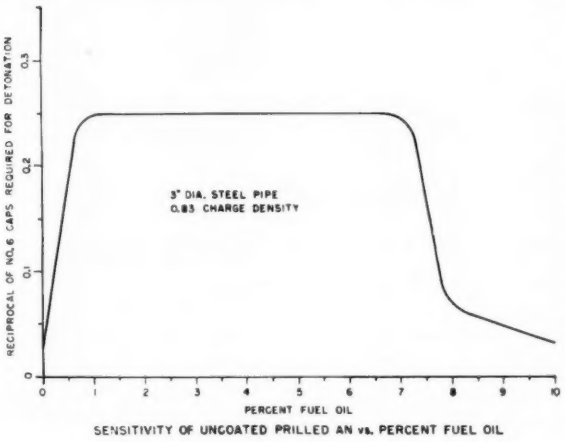


Fig. 5. The sensitivity remains essentially constant from one to seven percent fuel oil for the conditions of this sensitivity test. Good explosive design indicates that the percentage of fuel oil should not be dictated by sensitivity, but rather by the amount of energy which can be obtained

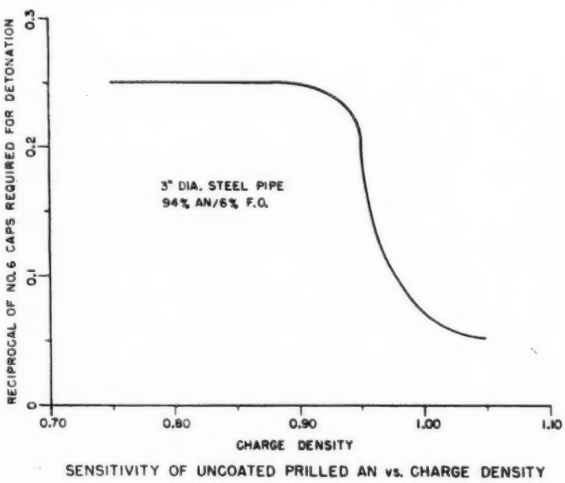
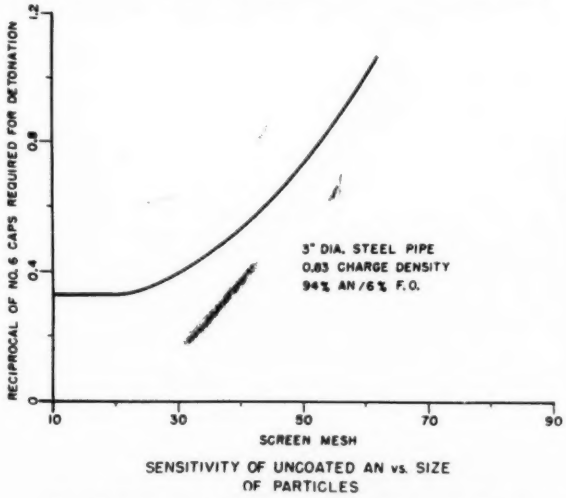


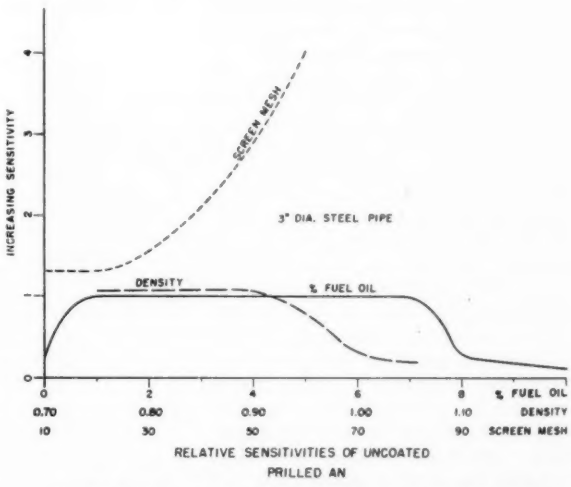
Fig. 6. Both bulk density and prill density affect sensitivity

In view of its importance, it is worthwhile to emphasize again that the sensitivity curve in figure 5 is for regular, porous, low density, fertilizer grade AN prills confined in three-in. pipe. The constant sensitivity from one to seven percent fuel oil applies only to porous AN prills. Sensitivity curves for other types of AN products will not necessarily be the same. For example, dense AN prills have their maximum sensitivity at approximately two percent fuel oil because the oil does not penetrate the surface as it will with porous AN prills. The maximum sensitivity was obtained by Cook[4] at approximately 1.5 percent wax coating content and confirms the results obtained with a comparable condition for dense AN prills coated with two percent fuel oil. Good explosive design indicates that the percentage of fuel oil should not be dictated by sensitivity, but rather by the amount of energy which can be obtained.

Sensitivity and Density

Both bulk density and prill density affect sensitivity. For a 94/6 AN-oil (porous prill AN) mixture the natural pouring density in a three-in. diam steel pipe is approximately 0.80 grams per cubic centimeter. Density can be increased to 0.90 by mechanical vibration of the pipe with the sensitivity remaining essentially constant. To obtain a charge density above 0.90 it is necessary to tamp the charge at frequent intervals as it is poured into the pipe. Some of the prills are crushed in the tamping process, thus effectively decreasing the particle size





Figs. 7, 8. Tests show that cap sensitive AN-fuel oil mixtures are easily obtained by grinding the AN to a minus 60-mesh size

as the density is increased. There is also some variation in charge density throughout the explosive column because of the intermittent compression. How much an effect the crushing of the prills and the non-uniform density has on the sensitivity, which showed a rapid decrease with increased density, could not be determined. The general shape of the curve, however, is in agreement with the general behavior of other explosives (figure 6).

Particle Size and Sensitivity

In the manufacture of most explosives, control of the grain size is important because the particle size of the explosive components may exert a profound influence on its blasting properties. Eyring's grain burning theory[5] explains on a fundamental basis the effects of grain size upon mass burning rate. Even though the fertilizer grade AN-fuel oil mixture is in reality a binary mixture, it can be regarded as approximating a homogeneous granular composition because of oil penetration into the prills. Accurate measurement of the variation of sensitivity as the particle size of the AN prills is varied over a wide range is difficult. The porous structure of AN prills has effectively reduced the grain size compared to that which would be normally related to a screen analysis. The manufacture of AN prills produces a uniform size product of approximately spherical prills in the range of minus 8 to plus 30 mesh. If a smaller screen size fraction is desired the prills must be ground. Grinding of AN prills completely destroys their spheroidal shape and particles of screen fractions smaller than plus 30 mesh have an angular, irregular shape. Care should be exercised in referring sensitivity to surface area of the fractions because a surface area ratio discontinuity exists between the plus and minus 30-mesh particles due to the change of particle shape. The results of the particle size sensitivity tests (figure 7) are for two separate kinds of AN: prilled AN from minus 8 to plus 30 mesh, and ground AN from 30 to 100 mesh. The sensitivity curve was plotted from data obtained from five screen size fractions, 10/12, 14/16, 30/60, 60/100, and minus 100. The relatively constant sensitivity of the prilled AN screen sizes, which encompasses the particle size range of fertilizer grade AN (8/20), strengthens the belief that sensitivity of fertilizer grade AN varies little from one manufacturer to another. One interesting fact is that cap sensitive AN-fuel oil mixtures are easily obtained by grinding to a minus 60-mesh size.

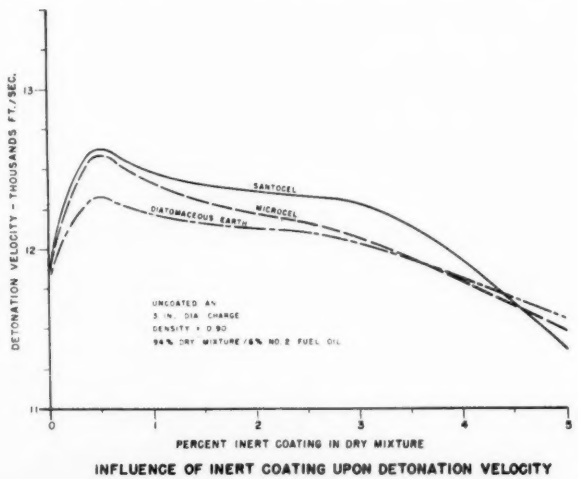
Table IV. Influence of particle size, shape, and structure on sensitivity

Mixture	*Min. No. of No. 6 caps reqd. for complete detonation*	*Remarks*
94% AN unc. prills 6% Fuel oil	4	Density 0.83 +20 mesh
94% AN RCP 6% Fuel oil	2	Density 0.88 −20 mesh
94% Flaked AN 6% Fuel oil	10	Density 0.88 ave. size 2 × 2 × 0.08 mm thickness
94% ("E-2")* prills 6% Fuel oil	Failed 35	Density 1.00 +20 mesh
94% ("E-2")* RCP 6% Fuel oil	Failed 35	Density 1.05 −20 mesh
94% ("E-2")* flaked 6% Fuel oil	10	Density 0.90 ave. size 2 × 2 × 0.08 mm thickness
94% ("E-2")* ground 6% Fuel oil	Unconfined d_c-1 in. 1	Density 0.80 65% −100 mesh
85% ("E-2")* prills 15% Aluminum	Unconfined d_c-1 in. 1	Density 0.86 +20 mesh

All charges were shot in three-in. diam steel pipes, 2½ in. in length except as noted. Mixtures were aged a min. of two hours.

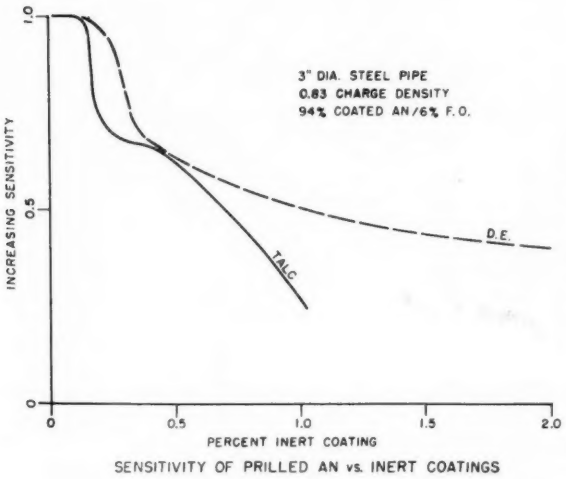
** Trademark name for dense, stabilized ammonium nitrate.*

A summary of the influences which particle size, shape, and structure have on the sensitivity of AN is presented in table 4. The effect of size is evident from a comparison between regular prilled AN and RCP AN. The latter is an undersize product from the manufacture of plus 20-mesh prills, a screen analysis of which can be found in an earlier report.[3] The influence which particle shape has on sensitivity is illustrated by comparison between dense flaked AN and dense AN prills, both of which have the same composition and structure but not bulk density. The possible reasons for the increased sensitivity of flaked material, which has roughly one-half the specific surface area of the dense AN prills, are not clear. Dense AN ("E-2") has approximately the same particle size and particle size distribution as regular AN, but the former is non-porous and capable of holding only about two percent fuel oil, mostly on the surface of the prills. An excellent illustration of the influence of the three factors discussed above can be seen in the comparison between the dense AN prills and the dense ground AN material. The high density prills and oil are very insensitive but when ground become very sensitive. However, packing factors related to particle shape cause a marked difference in density between the dense prills (1.00–1.10) and the ground state (0.80). The ad-



INFLUENCE OF INERT COATING UPON DETONATION VELOCITY

Fig. 9. The influence of inert material upon detonation velocity is readily detected in percentages as low as 0.2 percent



SENSITIVITY OF PRILLED AN vs. INERT COATINGS

Fig. 10. A very fine sized talc appears to reduce the confined sensitivity more than diatomaceous earth. The finer the particle size of the inert additive, the greater the reduction

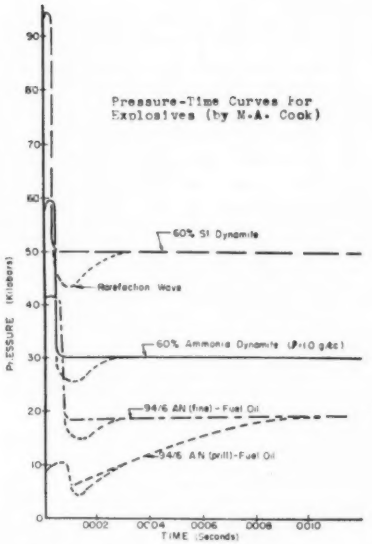


Fig. 11. Mass reaction rates and explosion state pressures have a definite influence on the shape of pressure-time curves

dition of aluminum to dense prills (table IV) resulted in a mixture which was cap sensitive.

Influence of Inert Coating on Sensitivity

The influence which inert coatings have on detonation velocities of AN-fuel oil mixtures was presented in an earlier report[3] and the results of the study are given in graph form (figure 9). The influence of inert material was readily detected in percentages as low as 0.2 percent. A very fine sized talc appeared to reduce the confined sensitivity more than diatomaceous earth. As might be predicted, the finer the particle size of the inert additive, the greater the reduction in sensitivity because of the larger surface area of the inert material (figure 10).

Desensitizing Effects of Dense AN Prills

The addition of dense AN prills to regular fertilizer grade prills has a marked desensitization effect as the percentage of high density prills increased. The sensitivity and detonation velocity measurements in table V were obtained by standard procedures. To eliminate density as a variable, as each mixture with a higher percentage of dense AN would have a slightly higher pouring density, all mixtures were tested at the common density of 0.90. The range of pouring densities was from 0.85 for the 90/10 AN/dense AN mixture to 0.90 for a 70/30 mixture. As little as ten percent of dense prills caused a marked decrease in the detonation velocity and a somewhat smaller decrease in the sensitivity. A 70/30 mixture exhibited a low order detonation as evidenced by a small crater formed in the ground immediately beneath the charge. It was difficult to induce a stable detonation wave in any mixture which had more than 40 percent of dense AN prills.

Table V. Effects of adding non-porous ("E-2")* to regular AN uncoated prills

Mixture	*Min. No. of No. 6 caps reqd. for complete detonation*	*Detonation velocity (fps)*	*Density gms/cc*
94% AN unc. prills 6% Fuel oil	4	11,200	0.83
94% 90% AN prills 10% ("E-2")* prills 6% Fuel oil	7	9,760	0.90
94% 85% AN prills 15% ("E-2")* prills 6% Fuel oil	8	9,600	0.90
94% 80% AN prills 20% ("E-2")* prills 6% Fuel oil	8	9,600	0.90
94% 70% AN prills 30% ("E-2")* prills 6% Fuel oil	20	—	0.90

All sensitivity measurements were made in three-in. steel pipes, 24 in. in length. Detonation velocity charges were 48 in. in length.
** Trademark name for dense, stabilized ammonium nitrate.*

Density Effects

The criteria normally applied in selection of the best explosive for a given set of blasting conditions are: (1) the detonation velocity, (2) available energy per unit weight, (3) the density of the explosive, and (4) pressure-time curve. For a very hard rock which is difficult to blast, one would select an explosive with a high detonation velocity and available energy and conversely for a soft, easily broken rock one would select a low velocity, low energy explosive. The application of these selection factors is, however, not applicable in all cases. Considerable blasting experience coupled with the use of the above criteria is necessary to insure the wisest choice of explosive. Of prime importance for the determination of the blasting action of an explosive is its pressure-time curve. From reaction rate data, theory of maximum available work, and equation of state of the explosive it is possible to approximate the p-t curves. However, this involves lengthy and tedious computations and is seldom done.

Some concept of the p-t curve may be obtained by calculating the explosion state pressure, or borehole pressure, and the approximate total reac-

tion time. These two quantities determine to some extent the shape of p-t curves. Cook has calculated the p-t curves for several common commercial dynamites and prilled AN-fuel oil mixtures.[4] The curves in figure 11 show the influence which mass reaction rates and explosion state pressures have on the shape of the curves. The more non-ideal the explosive, the greater is the deviation from the theoretical ideal p-t curve.

The calculation of the explosives state pressure can be made using the thermohydrodynamic theory. The detonation pressure, p_2, can be approximated by the equation:[4]

$$p_2 = 0.0009\rho_1 \frac{D^2}{4} \text{ atm}$$

where ρ_1 = original density in grams per cubic centimeter and D = detonation velocity in feet per second. A rough approximation for most solid explosives is that the explosion state pressure p_3, is one-half the detonation pressure or:

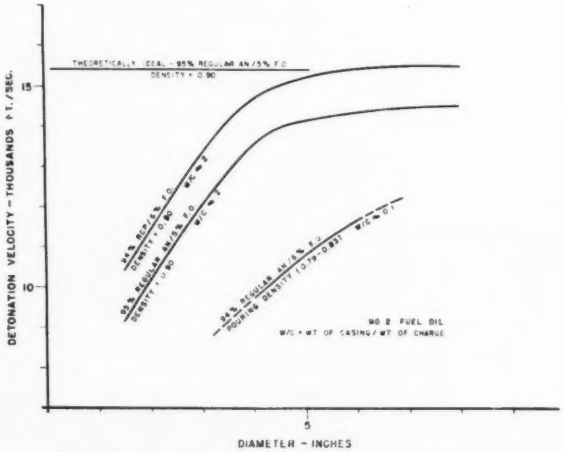
$$p_3 = \tfrac{1}{2}p_2$$

and

$$p_3 = 0.0009\rho_1 \frac{D^2}{8}$$

The calculation of reaction rates of explosives can best be accomplished with one of three "reaction rate theories" presently in use. Cook's "detonation head model" appears to be the most useful and most easily applied. A simplification can be made because only relative reaction rates are needed. In accordance with the detonation head model the fraction of chemical reaction completed in the detonation wave is expressed by:

$$N = \left(\frac{D}{D^*}\right)^2$$



Figs. 13, 14. The detonation velocity to charge diameter relationship for dense AN and regular AN prills

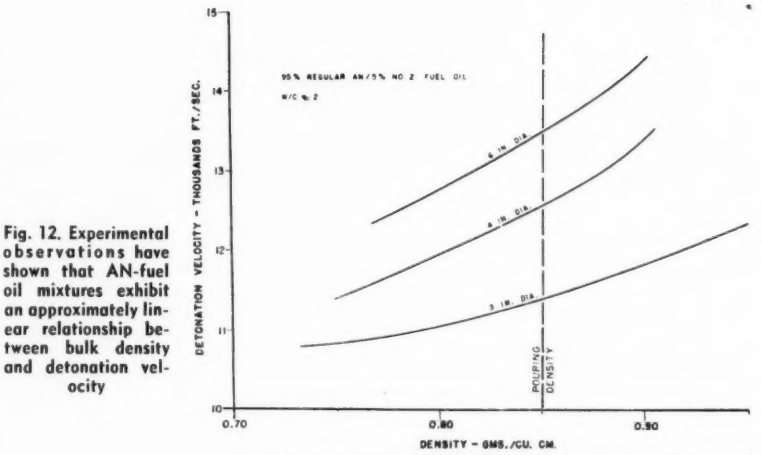
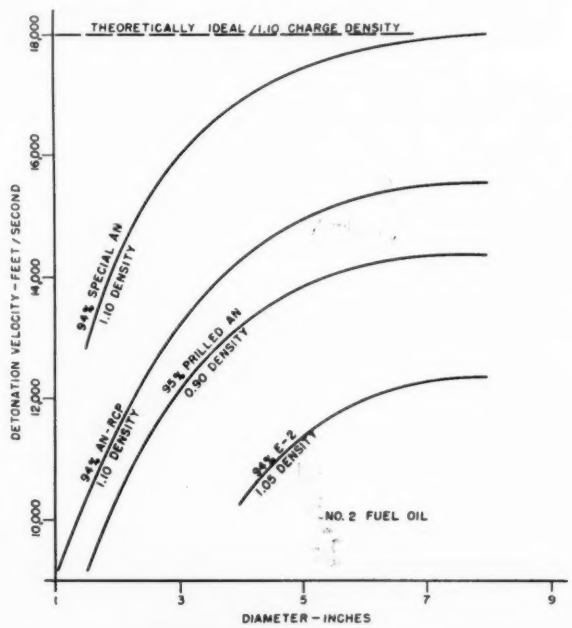


Fig. 12. Experimental observations have shown that AN-fuel oil mixtures exhibit an approximately linear relationship between bulk density and detonation velocity

INFLUENCE OF CHARGE DENSITY UPON DETONATION VELOCITY

The value N is a measure of the relative reaction rates, D is the actual and D* is the ideal velocity. This formula can be employed to compare the properties of the AN type explosives presently in use for large hole blasting. Explosion state pressure and borehole pressure are considered to be equivalent and the assumption is made that the loading density in the borehole is unity. In other words, the entire hole is completely filled with explosives. Velocities were measured in steel pipe, whose confinement corresponds effectively to a borehole in hard rock.

From the thermohydrodynamic theory, for a given ideal explosive, the detonation velocity is a function only of its density. Experimental observations have shown that AN-fuel oil mixtures also exhibit approximately a linear relationship between bulk density and detonation velocity (figure 12). In a six-in. borehole the maximum pouring density is approximately 0.85 with a corresponding D of 13,800 fps and a borehole pressure, p_3, of 21,000 atmospheres. With some device for down-the-hole vibration the density conceivably could be increased to a maximum of 0.90 with a D of 14,300 fps. For many types of rock such a mixture of prills and fuel oil is suitable, but for hard rock which is difficult to break, the borehole pressure may be too low. The most logical manner in which to increase



the borehole pressure would be to increase the density of AN-fuel oil mixtures. For explosives which can be poured into a hole, the bulk density can be increased by adjusting particle size and particle size distribution. It was found that the recirculate product from the production of plus 20-mesh prills had one optimum particle size distribution for maximum density. At a pouring density of 0.90 (figure 13) the detonation velocity of RCP in a six-in. borehole is 15,400 fps or just a few hundred fps less than the ideal detonation velocity. Under these conditions p_3 is approximately 27,000 atmospheres and N has a value of about 0.96. Thus, a reduction in over-all particle size increases D, p_3, and the mass reaction rate to practically that of an ideal explosive. However, in field tests it was found that the slight increase in blasting effectiveness attained by the use of fine AN was somewhat offset by increased difficulties in handling.

Particle shape was investigated as a possible means of increasing the pouring density. Although a flaked AN product with a density of 0.90 was obtained, its blasting performance was below that of regular AN prills. In a six-in. borehole the detonation velocity approached only 10,000 fps, which is far below the ideal rate.

Many investigators and users have resorted to the addition of a high density material to regular prills in order to raise the over-all density of the mixture. One such mixture consisted of 90 percent AN prills and ten percent sodium nitrate to give a density of 0.96. A 94/6 mixture in a six-in. borehole had the observed detonation velocity of only 12,500 fps, much lower than the ideal rate of 16,400 fps. Substances other than sodium nitrate have been tried in the field with substantially the same results.

Although the pouring density of high-density, stabilized non-porous AN prills was high, 1.05, the prills would not absorb six percent fuel oil. Practically all of the oil remains on the surface of the prills and consequently inhibits effective detonation in all but very large diameter charges. Figures 13 and 14 illustrate the velocity-diameter relationship for dense AN and regular AN prills. For dense AN in six-in. diam charges, D was observed to be 12,250 fps, which is considerably lower than the ideal rate of 17,400 fps. For this mixture, p_3 would be in the neighborhood of 21,000 atmospheres and N approximately 0.50.

A means was found to produce a dense ammonium nitrate product that would absorb oil and which proved to be a very effective blasting agent. This material with six percent fuel oil has a pouring density of 1.10 in a six-in. borehole. For a 94/6 mixture with a 1.10 density the observed detonation velocity in a six-in. diam pipe was almost 18,000 fps, or equal to the ideal rate. Therefore, the borehole pressure reached the maximum attainable value of 40,000 atmospheres and the percentage of reaction completed in the detonation wave was 100 percent. The blasting effectiveness of this special AN on a velocity-energy basis is equal to or exceeds that of a 60 percent straight dynamite or a 75 percent ammonium dynamite.

A comparison (table VI) of Special AN with AN-TNT-water slurry, of 65/20/15 AN/TNT/water composition, which has a density of 1.40, shows the observed D of the slurry for a six-in. diam charge is 19,700 fps or the ideal rate. The explosion pressure p_3 is approximately 50,000 atmospheres, compared to the p_3 of 40,000 atmospheres for Special AN. However, the total available energy per ft of six-in. borehole is only somewhat greater for the slurry because of the negative effect of water on the heat of explosion.

One of the most useful methods for determining the strength of an explosive is to calculate the maximum available energy, A. For any explosive which has a fast absolute reaction rate and short total reaction time, the theoretical value is a good approximation. Under the conditions outlined in table VI for those blasting agents which have a high value of N, no appreciable error is introduced if A is considered to be approximately equal to Q, the heat of explosion.

Table VI. A summary of the explosion parameters of some blasting agents

Mixture	*Pouring density*	*Det. vel. 6" diam.+ fps*	*D° fps*	*$P°_2$ 10^3 atm*	*P_3 10^3 atm*	*$N\left(\frac{D}{D°}\right)^4$*
94% AN prills (2% DE) 6% Fuel oil	0.85	13,800	15,200	46	21	.82
94% AN RCP (fines) 6% Fuel oil	0.90	15,400	15,600	55	26	.97
94% Flaked AN 6% Fuel oil	0.90	10,000	15,600	55	12	.41
94% 90% AN prills 10% SN 6% Fuel oil	0.96	12,500	16,400	63	19	.58
94% ("E-2")* prills 6% Fuel oil	1.05	12,250	17,400	73	21	.49
94% Special AN 6% Fuel oil	1.10	18,000	18,000	79	40	1.00
65 / 20 / 15 AN / TNT / water	1.40	19,700	19,700	118	59	1.00

D° ideal detonation velocity, $P°_2$ ideal detonation pressure, P_3 calculated + Steel pipe.

** Trademark name for dense, stabilized ammonium nitrate.*

Table VII. Maximum available energy for three blasting agents

	94/6 AN Prills/ FO	*94/6 Special AN/FO*	*65/20/15 AN/TNT/ Water*
Density	0.85	1.10	1.40
Det. vel. fps 6" diam. confined	13,800	18,000	19,700
Critical diam. in. unconfined	4	4	4
Borehole pressure $\times 10^3$ atm.	21	40	59
Max. available energy kcal per kg	920	920	760
Max. available energy per ft of borehole 6" diam. kcal	4,350	5,630	5,910
Relative energy per ft of borehole	1.00	1.29	1.36

Therefore, in table VII the maximum available energy values for the 94/6 AN prills and fuel oil and the 94/6 Special AN and fuel oil approximate the heats of explosion. The value of A for these two blasting agents would be approximately 30–40 kcal per kg less. However, the approximation of A = Q for the AN-fuel oil mixture does not introduce any appreciable numerical advantage over the TNT slurry explosive as the calculated A value was obtained under the assumption that water remains gaseous in the work process. This assumption may be incorrect if the final temperature is below the condensation temperature of water.

Special AN appears to have the same confined 1½-in. and unconfined, 4-in. critical diameter as the regular prills and oil mixture. The sensitivity, however, is lower, thus providing an even safer blasting mixture for field compounding and use. For regular prills and oil the recommended primer is any explosive having a detonation pressure greater than 60 percent ammonium dynamite or 40,000 atmospheres. This primer is also adequate for initiation of the special AN; however, a much stronger primer such as PETN is recommended. One reason is that at large diameters Special AN has a greater detonation velocity than the 60 percent AN dynamite primer. If the Special AN were to be initiated with a 60 percent dynamite primer, the detonation velocity of the AN would begin at a lower rate than its stable ideal rate. Actual velocity measurements have shown that detonation wave travelled as much as three diameters before it reached its stable rate of 18,000 fps.

Conclusions

Sensitivity and detonation velocity measurements are two important means of evaluating the blasting performance of explosives. Some observations resulting from the experimental data which may be of practical use to the operator are as follows:

1. A positive means of mixing the AN prills and fuel oil, such as in an ordinary concrete mixer, insures the greatest potential for obtaining the maximum available energy possible. The increased sensitivity, by virtue of the uniform composition, would help to eliminate the partially detonated holes which may occur.

2. AN-fuel oil mixtures which are mixed at least two hours before use attain near maximum sensitivity. Longer aging periods would be desirable as long as the mixture is protected from moisture.

3. The oldest stock of AN should be used first. Provided moisture is not allowed to penetrate the AN, the sensitivity and detonation velocity have been found to increase to a limited value as age increases.

4. Since sensitivity of fertilizer grade AN prills is constant from one to seven percent fuel oil, the amount of oil should be dictated by energy considerations which means a balanced mixture or approximately 5.7 percent fuel oil is best.

5. The smaller the particle size of the AN the higher the sensitivity of the AN-fuel oil mixtures. However, a compromise between particle size and density must be made because grinding not only decreases the particle size, but also the density.

6. Small percentages of inert coatings of as little as 0.2 percent on fertilizer grade AN prills lower the sensitivity of the oiled mixture, but have little effect on the detonation velocity.

7. Increasing the density of the fertilizer grade prilled AN-fuel oil explosive by tamping will increase the amount of available energy per ft of borehole. Caution must be exercised so that the density is not increased to such an extent that the mixture is too insensitive. Increasing the density of AN-fuel oil mixture by high density additives can be detrimental in the sense that the mixture can become less ideal and consequently the actual blast energy obtained is less than that of the regular AN-fuel oil mixture. High density AN products to be usable blasting agents must have a high mass reaction rate such as that of the dense special AN product described.

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As Viewed by HENRY I. DWORSHAK of the American Mining Congress

WHEN John F. Kennedy, Democrat of Massachusetts, is inaugurated January 20 as the 34th President of the United States, the ceremony will be witnessed by a Congress which remains firmly under the control of his party. This dominance should contribute to teamwork between the Executive and Legislative branches of the Federal Government in implementing the new President's program and policies.

Make-up of the 87th Congress, which will convene January 3, is as follows: Senate, 64 Democrats and 36 Republicans; House, 261 Democrats and 176 Republicans.

President Eisenhower has taken several steps to check the continued unfavorable balance of payments in United States foreign trade. All Federal agencies have been ordered to sharply reduce foreign spending, to be partly accomplished by a mandatory reduction in the number of dependents of military personnel abroad and, where practical, a reduction in the number of overseas civilian personnel and their dependents.

The President's announcement followed a November 15 report of the Commerce Department that the outflow of gold from the United States during July, August and September had increased to a rate equalling $4.3 billion a year, up from a rate equalling $2.9 billion a year during the preceding quarter. The Department said that if the $4.3 billion rate continued for the remainder of 1960, the total gold deficit for the year would amount to $3.5 billion.

FIRST QUARTER RESIDUAL OIL IMPORT QUOTA ANNOUNCED

Acting under authority of the Government's mandatory oil import control program, the Interior Department has limited licensed imports of residual fuel oil on the East Coast to an average of 530,000 barrels daily for the January–March quarter. This fuel, a residuary product resulting from oil refinery operations, has made inroads on coal's traditional markets in East Coast States; imports of it are limited to prevent further erosion of the country's mobilization base for coal production.

In announcing the quarterly ceiling, the Department said: "The maximum residual fuel oil import level was established on the basis of the actual level of imports in the first quarter of 1957, with adjustments to take into account declining domestic residual fuel oil refinery yields and current and prospective inventory levels. Recognition was also given to the high level of bonded residual stocks which could be made available for consumption in the United States on short notice should the situation warrant such action."

Residual oil imports approximated 439,000 barrels daily in the first quarter of 1957, base year of the control program, and 660,000 barrels daily in the first quarter of this year.

★ ★ ★ ★ ★ ★

Washington Highlights

GOLD: President takes action to stem outflow

RESIDUAL OIL: Import quota for first quarter announced

URANIUM: AEC report lists procurement data

COAL RESEARCH: Advisory committee named by Government

LEAD-ZINC: Import quotas will be continued

SILVER: Treasury asked to stop industrial sales

BUSINESS REPORTS: Court upholds secrecy of census data

★ ★ ★ ★ ★ ★

URANIUM PROCUREMENT IS MAJOR OPERATING COST OF AEC

Procurement and production of raw materials continue to constitute the major share of the Atomic Energy Commission's operating costs, the agency's annual report shows. Total of this category for the fiscal year which ended June 30 was $1.4 billion, about 55 percent of the year's operating budget of nearly $2.7 billion.

AEC noted that $717 million was spent for uranium and other raw materials, an increase of some $17 million over the previous fiscal year. Prices paid for uranium oxide produced in privately owned domestic mills averaged $8.78 per pound for the year, compared with $9.18 in the previous year. The average over-all cost for uranium from both domestic and foreign sources in fiscal 1960 amounted to $10.19 per pound, 15 cents per pound less than in 1959.

In the area of reactor development, AEC expended almost $400 million in 1960, an increase of about $45 million over 1959. Of this total, the agency spent $118 million in the civilian reactor program, about $213 million for the development of military reactors, and some $68 million for general reactor research and development.

The report also shows that, beginning with July 1, 1960, the aggregate quantity of uranium oxide in concentrates that has been contracted for under all outstanding contracts with domestic milling companies is approximately 190.7 million pounds, of which 74.3 million pounds are scheduled for delivery by the end of 1962 and 116.4 million pounds in the following four years.

Estimated cost to the Government of these deliveries is nearly $1.6 billion, of which $621.3 million will fall in the first period and $931.5 million in the following period. These figures do not include additional purchases which will result from contract extensions yet to be negotiated, the report noted.

GOVERNMENT NAMES COAL RESEARCH ADVISORY COMMITTEE

Appointment of a 14-member committee to serve as an advisory group to the recently created Office of Coal Research has been announced by the Interior Department. The committee will assist the new agency in selecting short-range research projects to supplement Bureau of Mines work.

Members of the Coal Research Advisory Committee are: Raymond E. Salvati, president, Island Creek Coal Co., Huntington, W. Va., and president, American Mining Congress; Morris H. Bigelow, technical adviser, Allied Chemical Co., New York, N. Y.; H. B. Charmbury, head, Department of Mineral Preparation, Pennsylvania State University, University Park, Pa., and chairman, Coal Research Committee, American Mining Congress Coal Division; F. S. Elfred, board chairman, Peabody Coal Co., St. Louis, Mo.; J. D. Jillson, president, Anthracite Institute, Wilkes-Barre, Pa.; Harry LaViers, president, South-East Coal Co., Paintsville, Ky.; Samuel Lenher, vice president, research and development, E. I. DuPont de Nemours & Co., Wilmington, Del.; S. T. Saunders, president, Norfolk & Western Railway Co., Roanoke, Va.; Walter K. Scherer, president, Fred Scherer, Inc., Ottawa, Ill.; G. A. Shoemaker, president, Consolidation Coal Co., Pittsburgh, Pa.; G. R. Spindler, dean, West Virginia School of Mines, Morgantown, W. Va.; Philip Sporn, president, American Electric Power Co., New York, N. Y.; William L. Wearly, president, Joy Manufacturing Co., Pittsburgh, Pa.; and Michael F. Widman, Jr., director of marketing and research, United Mine Workers of America, Washington, D. C.

QUOTAS ON LEAD-ZINC IMPORTS WILL BE CONTINUED

The White House has announced President Eisenhower's concurrence with a recent Tariff Commission finding that conditions do not warrant any change in the current mandatory quotas on imports of lead and zinc. These quotas were instituted October 1, 1958, following an escape-clause case in which the Commission found that excessive imports of the two metals were injuring the domestic lead-zinc mining industry.

According to the announcement, "the President's decision means that the import quotas will continue to apply." The Tariff Commission's next periodic review of the lead-zinc situation is scheduled for September 1961.

TREASURY URGED TO END SALES OF SILVER TO INDUSTRY

Secretary of the Treasury Robert B. Anderson has been urged to order immediate "termination of the sale of Federally owned silver to industry" in order to safeguard the Treasury's dwindling reserves of free, or nonmonetized, silver.

In a December 1 letter to the Secretary requesting the action, Senator Dworshak (Rep., Idaho) noted that "a heavy demand for the coinage of subsidiary silver coins continues" which, coupled with "materially increased" sales of silver to industry, indicates that free silver owned by the Treasury "will last less than two years at the present rate of erosion."

Demand for silver is rapidly exceeding available supplies, he wrote, which he said meant that the price of silver would likely go beyond 91 cents except for the Government's policy of selling silver at that price.

"Our domestic minerals industry is in urgent need of stabilization," he stated, "and higher prices for silver, especially when produced as a by-product of lead, zinc, and copper, would greatly strengthen this industry and provide much needed employment for miners."

COURT UPHOLDS SECRECY OF REPORTS TO CENSUS

By declining to review a lower court decision barring the Federal Trade Commission from inspecting a business report filed with the Census Bureau by a Chicago company, the U. S. Supreme Court has in effect upheld the secrecy of such reports.

The Supreme Court's refusal thwarts attempts by the FTC and the Justice Department's Antitrust Division to obtain access to confidential census information to expedite anti-merger and antimonopoly inquiries.

This case arose when the Census Bureau—with the full support of the Budget Bureau as the agency which coordinates Government gathering of statistics—insisted that its data on the company remain confidential. Census officials noted that when they solicit reports they promise that the material will remain secret and "cannot be used for purposes of taxation, investigation or regulation." To treat the information otherwise, they said, would be morally wrong and would hamper their agency's job of gathering accurate statistics on the economy.

In rejecting the FTC attempt to compel the Census Bureau to turn over the data, the lower court stated: "The United States has given its word and should be permitted to keep it."

THE REPORT CORNER

Recent Publications of Interest to Mining Men

U.S.B.M. Information Circular 7995, "Testing and Splicing Electric Cables and Frame-Grounding Pit Equipment, Tecumseh Coal-Strip Mine, Boonville, Ind.," by Sanford J. Douglas.

U.S.B.M. Report of Investigations 5683, "Reducing the Incendivity of Permissible Explosives by Sodium Chloride," by N. E. Hanna, G. H. Damon and R. W. Van Dolah.

U.S.B.M. Report of Investigations 5681, "Combustion of North Dakota Lignite in Domestic Heaters," by W. H. Oppelt, W. R. Kube, R. B. Porter, T. W. Kamps, O. C. Ongstad and E. F. Golob.

U.S.B.M. Report of Investigations 5677, "Solvent Extraction of Coals by Abietic Acid at Atmospheric Pressure," by E. C. Tarpley and H. C. Howard.

U.S.B.M. Report of Investigations 5685, "Acid Curing and Countercurrent Decantation Washing of an Oxidized Copper Ore from Pinal County, Ariz," by W. A. McKinney and Carl Rampacek.

U.S.B.M. Report of Investigations 5674, "Producing Heavy Fuel Oil by Hydrogenating Bituminous Coal," by Henry H. Ginsberg, Paul S. Lewis, Robert B. Anderson and Raymond W. Hiteshue.

U.S.B.M. Report of Investigations 5673, "Hydrogenating Coal in a Pilot Plant With a Molybdenum Catalyst," by Henry H. Ginsberg, Sam Friedman, Paul S. Lewis, M. D. Schlesinger, Arthur J. Stewart and Raymond W. Hiteshue.

U.S.B.M. Report of Investigations 5672, "Ceramic Fibers for Filtering Dust From Hot Gases," by L. J. Kane, G. E. Chidester and C. C. Shale.

U.S.B.M. Report of Investigations 5671, "Minimum Ignition—Energy Concept and Its Application to Safety Engineering," by E. L. Litchfield.

U.S.B.M. Report of Investigations 5666, "Underground Gassification of Coal; Hydraulic Fracturing as Method of Preparing a Coalbed," by J. P. Capp, J. L. Elder, C. D. Pears, R. W. Lowe, K. D. Plants and M. H. Fies.

Note: U.S.B.M. Information Circulars and Reports of Investigations can be obtained from the Publications—Distribution Section, Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa. They should be requested by number and title.

personals

H. A. Sawyer, chairman of the board and president of Lone Star Cement Co., was recently elected chairman of the board of directors of the Portland Cement Association at its recent annual meeting in Chicago. He succeeds **Cris Dobbins,** president of Ideal Cement Co., who has served as chairman of the Association's board of directors for the past two years.



Sawyer entered the cement industry in 1923 as a field engineer for the Portland Cement Association. Two years later, he joined Lone Star Cement as a service engineer and by 1952 had risen to president, director, and member of the executive committee. In 1959, he was elevated to the additional post of chairman of the board. He is also president and a director of Lone Star's subsidiaries in Argentina, Uruguay and Cuba. Sawyer is a member of the board of directors of the American Mining Congress and chairman of the AMC advisory committee for the cement industry.

Alan H. McBane has been elected vice president of Valley Camp Coal Co. McBane, previously general manager of Valley Camp's operations in Kanawha County, W. Va., has been with the company since 1934.

Richard V. Colligan has been elected vice president of Freeport Sulphur Co. He has spent most of his 20 years with the company in pursuit of its minerals interests in Cuba. His last post, which he retains, is that of president of the Moa Bay Mining Co., a Freeport subsidiary which produced nickel and cobalt concentrate before its facilities were seized by the Cuban Government in August.



Colligan was first employed as an assistant geologist by Cuban Mining Co., a Freeport subsidiary which produced manganese in Cuba. He became mining superintendent in 1943 of Nicaro Nickel Co., another subsidiary, which designed, built and operated the Nicaro plant in Cuba for the United States Government until 1947. He returned to Cuba in 1951 to conduct exploratory and development operations in the Moa Bay area. He was elected vice president of Moa Bay Mining Co. in 1956, and president and a director in May 1959.

Clinton C. Cornelius has been appointed executive vice president of Emerald Coal & Coke Co., a J. H. Hillman & Sons Co. subsidiary. He had been vice president of engineering, and before joining Emerald, he was general manager for U. S. Fuel Co. Prior to that, he was with Baton Coal Co. for about ten years and earlier he was employed by Pittsburgh Coal Co.



Gordon H. Chambers has resigned as chairman of Foote Mineral Co., but he will continue as a member of the board. Chambers, who has been with Foote since 1928, has been chairman since 1956.

James C. Gray, administrative vice president—raw materials, U. S. Steel Corp. has been elected president of the Society of Mining Engineers of AIME for 1961. He will succeed **Arthur B. Cummins** of Bound Brook, N. J., on February 28, 1961. **William E. Stephenson,** president of Allen-Sherman-Hoff-Pump Co., has been named president-elect for 1962.

A. J. Teske, secretary, Idaho Mining Association, has been elected chairman of the Western Governor's Mining Advisory Council. **R. W. Beamer,** executive secretary, Wyoming Mining Association and **Frank P. Knight,** director, Arizona Department of Natural Resources, became vice chairman and secretary, respectively.

William H. Ritter, president of Reitz Coal Co., retired recently. He will continue as a director and consultant to the company. **Robert H. Seese,** general manager, Berwind-White Coal Mining Co., has been elected to succeed Ritter as president as Berwind-White assumes the management of Reitz.

Vincent D. Perry, vice president and chief geologist, Anaconda Co., was recently named by the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers as the 1961 recipient of its Jackling Award and as the Jackling Lecturer at AIME's annual meeting on March 1, 1961. The award is in honor of D. C. Jackling, and is presented for "significant contributions to technical progress" in mining, geology and geophysics.



Freeman Coal Mining Corp. announces the employment of **Paul M. Budzak** as director of safety. Assisting Budzak are **Frank Kolisek,** safety inspector and **Dayton McReaken,** recently promoted to safety inspector. All three have had long experience in the coal mining industry, and each includes several years in safety work among this experience.

J. K. Richardson, vice president, Glover Associates, Inc., has been transferred from Montreal, Que., to San Francisco, where a newly established office in the firm will make its management consultant services available to clients in the Western United States. Before joining Glover in 1959, Richardson was assistant general manager of the Chino Mines Division, Kennecott Copper Corp., and earlier secretary of the Utah Mining Association. Glover's San Francisco office is in the Equitable Life Bldg., 120 Montgomery St.



M. W. Reed, executive vice president, international and raw materials, U. S. Steel Corp., is retiring December 31. Reed has been with U. S. Steel since 1916, when he joined American Steel & Wire Co. as a wire tester. He became vice president-engineering of U. S. Steel Corp. of Delaware in 1949, and in 1951 was advanced to executive vice president, engineering and raw materials. He was elected to his present post in 1958.

Greenleaf Clendenin recently became assistant superintendent of Robin Hood mine, Coal Division, Armco Steel Corp. Other appointments include naming **Carl Javins** general foreman of the Montcoal mine and **Buster Bradley** assistant general foreman.

C. W. Davis was reelected president of the Southern Coal Producers' Association at its annual membership meeting November 14. **Laurence E. Tierney, Jr.,** treasurer, and **John F. Lane,** secretary, were also reelected. Tierney is president of Eastern Coal Corp., and Lane is a partner in the Washington law firm of Gall, Lane and Howe.

Two appointments to newly created positions at Utah Copper Division of Kennecott Copper Corp. were recently announced. **Wayne Burt** has become superintendent of smelting and refining operations, and **Ray Gough** will assume the same position for mining and concentrating. Burt has been associated with Kennecott since 1944 when he joined Braden Copper Co., a subsidiary. In 1958 he became milling superintendent of the Arthur mill. Until he became general superintendent at Utah, he had been refinery superintendent. Gough has been with Kennecott for ten years. He was assistant mine superintendent from 1956 to 1958, when he became operations superintendent, the position he held at the time of his recent advancement.

Stephen Canonico was recently elected president of the West Virginia Coal Mining Institute. Canonico is a vice president of both Clinchfield Coal Co. and Elk River Coal & Lumber Co.

Inland Steel Co., following acquisition of Pacific Isle Mining Co., has announced several personnel changes. **Bob Lacke** has been named superintendent of the Iroquois mine. He was formerly superintendent of the Greenwood mine on the Marquette iron range where he has been succeeded by **Bud Annear. Dino Pirolo,** formerly senior mining engineer at the Armour mine became operating engineer at the Greenwood. **Tom Tweed** succeeds Pirolo as senior mining engineer at the Armour.

G. A. Shoemaker, president, Consolidation Coal Co., was recently named to the National Corporations Committee of Freedoms Foundation. The committee, which is made up of leading business and industrial executives, combats Communist efforts to weaken the free enterprise system.

Roy Jure has been appointed manager of the Exploration Department of American Metal Climax, Inc. He was formerly assistant manager and he succeeds **Jack A. James,** who recently resigned to engage in private geological consulting work with headquarters at 211 Bellaire Road, Ridgewood, N. J.

Ben T. Phillips, mine surveyor at the Carlsbad, N. M., operations of International Minerals & Chemical Corp., was recently promoted to mine project engineer. He joined International in 1956 as a junior mining engineer, prior to which he was employed by Unger Exploration Co.

Charles A. McKinley was recently named general manager of Trout Mining Company's silver-lead-zinc and manganese dioxide mining and milling operations at Phillipsburg, Mont. Prior to joining Trout, McKinley was general manager of Sidney Mining Co.

William Rule was recently named superintendent of the M. A. Hanna Co. semi-taconite iron ore plant being erected at Nashwauk, Minn., on the Mesabi iron range. He had previously been associated with Minerva Oil Co. Earlier he had been with Tennessee Copper Co. and Eagle-Picher Co.

OBITUARIES

William Roderick Easley, 53, former vice president and general manager of Mohave Mining & Milling Co. and president of Mohave Engineering & Equipment Co., died during the week of October 17 following a heart attack suffered on October 13.

Mr. Easley joined Western Knapp Engineering Co. in 1934 as an electrical engineer and subsequently became a construction superintendent for the company, handling many jobs in ore processing. In 1947, he became manager of the Western Division for WKE, where he supervised design, engineering and construction on various ore treatment projects. He left WKE in 1955 to enter private business and most recently was with Mohave Mining & Milling Co.

Kuno Doerr, Jr., 57, president of Southern Peru Copper Corp., died in Lima, Peru, on October 13.

Mr. Doerr became president of Southern Peru in 1958, before which he was manager of the Garfield, Utah, smelter of American Smelting & Refining Co. and president of Garfield Mfg. Co. He had joined Asarco at Garfield in 1927 as a chemist.

C. N. Crichton, 48, vice president of Johnstown Coal & Coke Co., died in Johnstown, Pa., November 11.

Robert W. Hughes, 68, former vice president and general manager of Miami Copper Co. died in Phoenix, Ariz., on September 10. Mr. Hughes, who had been employed in the Globe-Miami, Ariz., mining district for about 42 years, had served the company in an advisory capacity since his retirement in 1957 for health reasons.

Henry W. Saunders, 83, retired chief engineer of Mill Creek Coal & Coke Co., died in Ft. Lauderdale, Fla., on October 24.

Mr. Saunders, a native of Canada, came to the United States in the early 1900's and became associated with United States Coal & Coke Co. in 1903. He remained in the coal industry over the years with various companies and in 1921 became chief engineer for American Coal Co. From 1927 until he retired in 1952, he was chief engineer for Mill Creek.

Robert Y. Jensen, 39, assistant chief engineer, M. A. Hanna Co., died October 9 in an airplane accident near Victorville, Calif.

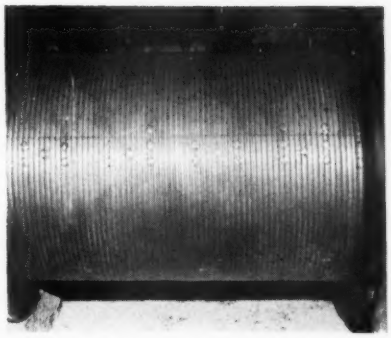
Mr. Jensen was a sales engineer with Ingersoll-Rand Co. in the northern Minnesota mining district for four years prior to joining M. A. Hanna Co. in 1951 as a mechanical engineer in their Minnesota operations. In 1956, he was transferred to Cleveland, Ohio, as assistant chief engineer.

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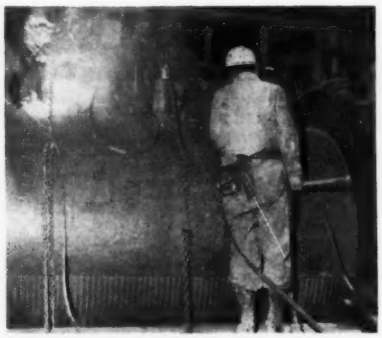
RESTORE WORN DRUMS

WITH LEBUS GROOVING

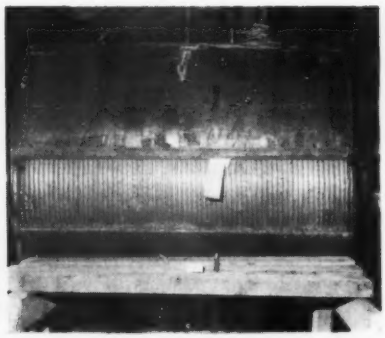
Here is one of several methods available for restoring your worn drums by the LeBus Spooling System, either on cast iron or steel drum. Wire line size may be changed in the same operation. Photos below show installation of LeBus Spooling System on a helical grooved steel drum.



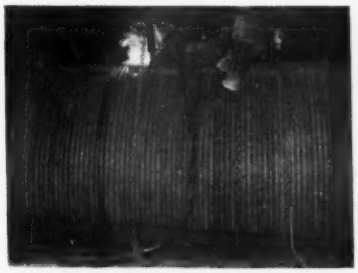
(1) Shows a 60" by 90" helical grooved steel drum before installation of LeBus Counterbalance Spooling System.



(2) Installation of one-half of steel split sleeve being welded and bolted over old drum core.



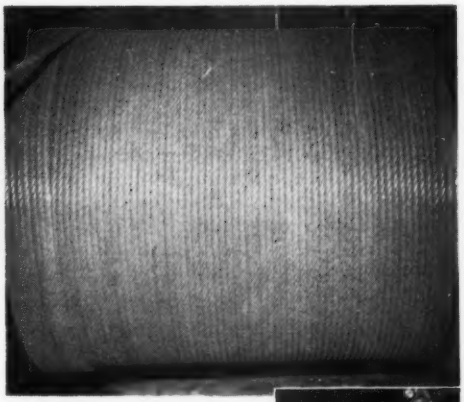
(3) Second half of steel split sleeve being put in place before welding to drum core.



(4) Installing LeBus grooved segments over steel split sleeve by method of welding firmly to the drum.



(5) View of completely restored drum being finished by grinding welds smooth in preparation for spooling the line on drum.



(6) Showing 8500 feet of 1-¼" wire line being spooled on seventh layer successfully and safely by LeBus Counterbalance Spooling System.



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Box 2352, Longview, Texas Phone: PLaza 8-5522

Fairmount Machinery Company
P. O. Box 992 Telephone: 1672
Fairmount, West Virginia

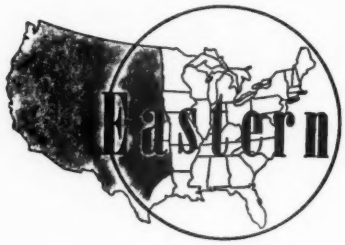
Salmon and Company
P. O. Box 2388 FAirfax 4-0625
Birmingham, Alabama

Western Machinery Company
P. O. Box 1498 CHapel 2-1983
Grand Junction, Colorado

Western Machinery Company
P. O. Box 2548 INgersoll 2-1983
Salt Lake City, Utah

The Coeur D'Alenes Co.
Wallace, Idaho

NEWS and views



Long-Term Contract for Coal Signed

Negotiations for a $50,000,000, ten-year coal purchase agreement extending through 1970 has been completed by Public Service Co. of Indiana, Inc., and Walter Bledsoe & Co., Viking Coal Corp. and Snow Hill Coal Corp. The agreement, a forward looking extension of a long-term contract between the two companies, calls for Public Service to purchase an estimated 13,000,000 tons of coal from the Bledsoe companies during the next ten years.

Under terms of the new agreement, the Bledsoe companies will produce an estimated 1,300,000 tons of coal annually to meet the entire annual coal requirements of Public Service's Dresser and Wabash River generating stations at Terre Haute, Ind.

Public Service will purchase the entire annual coal output of 675,000 tons from the Viking mine of Viking Coal Corp., and 625,000 tons annually from the Green Valley mine of Snow Hill Coal Corp. Bledsoe has announced the expenditure of more than $1,725,000 for the installation of new mining equipment to facilitate coal production at those mines.

INCO to Triple Capacity of Iron Ore Recovery Plant

The International Nickel Company of Canada, Ltd., is expanding its iron ore recovery plant at Copper Cliff, Ontario—tripling its capacity.

Using a process invented by the company's research staff and successfully established in its existing iron ore recovery unit, the expanded plant will treat 1,200,000 short tons per year of nickeliferous pyrrhotite high in iron content. The process involves solid state pyrometallurgical operations, and the removal of nickel by atmospheric pressure leaching.

The expanded plant is scheduled to be in full operation in 1963. It will entail a total estimated capital outlay of $50,000,000, of which up to $10,000,000 is scheduled for 1961.

AMC COAL DIVISION HOLDS ANNUAL CONFERENCE

Several hundred mining men and equipment manufacturers attended the highly successful Coal Division Conference of the American Mining Congress November 17–18 in Pittsburgh.

The program for the first day, November 17, was devoted to Radioisotopes in the Coal Industry. It was sponsored by the American Mining Congress and Bituminous Coal Research, Inc., in cooperation with the Atomic Energy Commission. Speakers described operations where this new tool is being used and discussed potential areas of application in the coal industry.

On Friday, November 18, the seven AMC Coal Division Committees summarized the results of their work during the past year. Featured at the luncheon was an address on "The Office of Coal Research" by Royce A. Hardy, Assistant Secretary, Department of the Interior. A concise report of the meeting will appear in the January issue of Mining Congress Journal. Look for it!

Marquette Acquires North American Cement

Marquette Cement Manufacturing Co. and North American Cement Corp. have announced the execution of an agreement providing for the acquisition of the business and assets of North American by Marquette. Marquette will assume the liabilities of North American and will issue 575,158 common shares of Marquette to North American for distribution to North America's shareholders.

Subject to the approval of the shareowners of the respective corporations, and to certain other conditions, it is contemplated that the transaction will be consummated on or before January 20, 1961.

Peabody Opens New Mine

Construction of Peabody Coal Company's new coal mine in Ohio was completed in November 1960. This operation is called Sunnyhill Mine No. 9 and replaces the production of Sunnyhill Mine No. 8, which will be closed.

Using a stripping shovel that takes 95 tons of overburden in a single bite, the mine will have a capacity of 2,000,000 tons annually. Its new preparation plant contains the latest design and most improved facilities for crushing, washing, sizing, heat drying and loading of coal. A special feature is the plant's fluid bed thermal drying system.

Twenty-Second Annual Mining Symposium

The twenty-second annual Mining Symposium, scheduled for January 10–11, 1961, Duluth, Minn., will be held in cooperation with the Annual Meeting, Minnesota Chapter of AIME, January 9, 1961. As was the case in 1960, the chapter and the University of Minnesota's School of Mines & Metallurgy and Center for Continuation Study are presenting a joint program covering 2½ days. The 1961 program will concentrate on factors affecting the future of Lake Superior iron ores.

Tobin Mine Head Frame Revamped

As part of an extensive modernization program, an above-ground screening plant is being constructed at Republic Steel's Tobin Mine, Crystal Falls, Mich. The task is under the direction of the engineering and structural steel divisions of Lake Shore, Inc.

Three large hoppers—two of 70-ton capacity to handle ore of different grade sizes, and a third to receive crushed rock from underground mine development—are being constructed.

Built as an integral part of the head frame, the new hoppers are suspended from the structure immediately under the crusher which is built into the head frame. The hoppers will load into both rail cars and trucks. Stockpiling, formerly a rail operation, will be done with trucks when the new plant goes into operation.

Inland Steel Acquires Pacific Isle

Inland Steel Co. has acquired full ownership of Pacific Isle Mining Co. It had been owned jointly by Inland and Pittsburgh Pacific Mining Co.

Pacific Isle, which will continue to operate iron ore mines on the Mesabi Range in Minnesota, has sold to Pittsburgh Pacific its interest in Coons Pacific Co.

Hugh H. Harrison, previous president who founded the company in 1946, and two other Pacific Isle executives will join Pittsburgh Pacific. Henry Hart, vice president now, will become the operating head of Pacific Isle.

Through Pacific Isle, Inland will operate the Iroquois mine at Mountain Iron, Minn., its first open pit operation on the Minnesota ranges since 1953.

ALSO . . .

The United Mine Workers will actively promote "all electric living" because the future of coal is closely tied to the growth of electric utilities. The 2000 delegates to the recent UMW convention in Cincinnati, Ohio, also heard several other ideas for promoting the use of coal. These ideas included use of coal as a paving binder base, use of pulverized coal for locomotives, and extraction of gases from coal for distillation of various chemicals. The UMW added that it would continue to fight the expansion of natural gas into traditional coal markets.

The American Iron Ore Association states that 100,156,109 tons of iron ore have been received at iron and steel plants in the United States and Canada this season through September 30. The comparable figure last year was 70,610,052, reduced by the steel strike. In 1957, the last "normal" year, it was 108,730,561 tons. Consumption of ore to date was 88,248,702 tons, compared with 79,043,219 this time last year and 102,070,690 at the same time in 1957.

Cannelton Coal Co. of Cannelton, W. Va., celebrated its 50th anniversary on November 18 with an open house and a tour of its plant and newly designed offices. The company's history in the Kanawha Valley extends back to 1857 through predecessor companies, when coal was first taken from the mines in sacks and bags. The major portion of its output today is used by the Algoma Steel Corp., Ltd., in Sault Ste. Marie, Ontario.



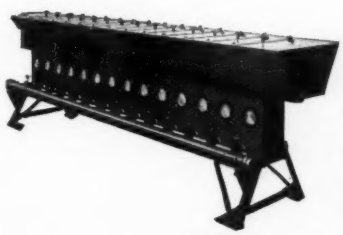
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STYLE D-1

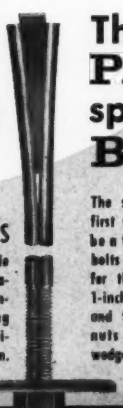
The unique double expansion feature of all Pattin expansion shells insures *dependable* roof support, in hard or soft roof conditions. Their double holding power guards against failure — even under a 20 ton pull!

Pattin features include a parallel contact with the hole, and no definite drilling depth is required, as the shell can be securely anchored at any place in the hole. They anchor solidly and will not turn while being tightened. Wedge and shell are assembled in a manner to prevent loss of parts in handling, and the bolt and shell assembly are furnished as a complete unit. Plates are bundled separately. No special nuts or ears are required on the bolts. These features make a safer roof — and a safer roof means fewer accidents, increased production, more clearance for equipment operation and better ventilation.

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The PATTIN split-type BOLT

The split-type bolt is one of the first slotted bolts, and continues to be a favorite wherever split-type bolts are used. Many mines still prefer this type. The bolt is a full 1-inch in diameter, with cut threads and furnished with hex or square nuts and various size plates and wedges.

IN WESTERN STATES

Pattin expansion shells are available and serviced exclusively by Colorado Fuel and Iron Corporation, Denver, Colorado. Western mining companies should contact them direct for information and consultation.

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ALSO . . .

A coal gasification plant, which will use nuclear energy, has been promised to West Virginia, according to a statement by Governor Cecil Underwood. The plant will be part of a Government project known as "Turret." The first experimental reactor to produce heat by nuclear energy is being designed in Atomic Energy Commission laboratories at Los Alamos, N. M. The location of the new West Virginia plant has not yet been decided.

The Tennessee Copper Company's liquid sulfur dioxide plant, destroyed by fire September 7, is being rebuilt at Copperhill, Tenn.

For the first time in South African colliery history, coal will be pumped from a coal mine to a power station, according to the magazine, *Coal and Base Minerals of Southern Africa.* The mine in which the pumping station for the pipeline will be constructed is Federale Mynbou's Koornfontein Colliery, while the new Escom Komati power station, 1½ miles away, will incorporate the coal dewatering arrangement. Between these two points minus ¾-in. coal will be conveyed via a nine-in. diam pipeline at the rate of 100 tph. Escom engineers stated that the cost of conveying coal through pipe was considerably less than using track or conveyor.

Michigan Chemical Corp. has acquired the Atomic Energy Commission's large rare-earth ion-exchange facility which is located at the company's plant area in St. Louis, Mo. The unit was originally built by Michigan Chemical for production of rare earth oxides for AEC. Now it will be used for research on the properties of rare earth elements and development of potential markets.

Russia is reportedly building two factories in coal mining areas to manufacture resin-bonded glass fiber pit props. The tubular props, about six ft long, will have a diameter of 2½ to 3½ in. and weigh 25 to 28 lb. They are reported to be two to three times cheaper than the metal kind. The British National Coal Board made a trial with fiber-glass pit props about three years ago, but found that, in the course of time, the bottom of the prop began to powder away and had to be shod with a steel sleeve. Britain is now advancing cautiously towards employment of this material in certain components of her hydraulic pit props, though retaining the main steel cylinder.

Construction Aggregates Corp. recently completed one of the largest hydraulic dredging projects in history. It involved the moving of over 160,000,000 cu yd of mud, water, silt, clay, and rock to uncover what will become Inland Steel Company's largest single source of iron ore. Inland expects to ship 750,000 tons of ore this year from the mine, which is operated by Caland Ore Co., an Inland subsidiary. The project, which is located at Atikokan in southern Ontario, is expected to reach a 3,000,000 ton per year level by 1969.



Program Committee Drafts Outstanding Convention Program for . . .

1961 AMC COAL SHOW

Top officials in Government and in the coal mining industry are slated to participate in the program at the 1961 Coal Show of the American Mining Congress in Cleveland, next May 15–18.

The Program Committee, at a meeting in Pittsburgh November 16, boiled down the numerous suggestions received from throughout the industry into a hard-hitting program designed to stimulate progress and bring the industry abreast of the latest advances in coal mining and preparation technology. Headed by F. S. Elfred, chairman of the board of Peabody Coal Co., this nation-wide committee of mine operators and equipment manufacturers deserves a special vote of thanks for a job well done.

An opening session on Monday morning, May 15, with addresses of broad general interest will set the stage for an intensive week of "schooling." Ten technical sessions have been arranged to cover practical coal mine operating problems, including underground and strip mining operations, coal preparation, safety, and management techniques. In addition, there will be a special session on cost cutting—open pit and underground—based on developments in the industrial minerals field. A general outline of the Convention program appears below.

The 1961 Coal Show will feature an Exposition of mining equipment that promises to be the most comprehensive ever held. Because the Exposition goes on a three-year basis after 1961—with the next succeeding Coal Show not scheduled until 1964—it is now more important than ever for mining men to attend. Coal mining is in the throes of changing from an art to a science, and progressive operators know that they must stay on top of new developments and ideas if they are to remain competitive. What better place to do this than the 1961 Coal Show, where more companies will be exhibiting more products for use in the nation's coal mines than ever before? This event is a "must" for Mr. Coal Man's 1961 schedule.

The "fun" side of the Coal Show is not neglected either. Plans are being made for a full schedule of entertainment for both mining men and their ladies, centered around the annual Coal Miners' Party—always a highlight at these meetings. A special program of ladies events is also being arranged. And, of course, there will be the customary round of individual parties and impromptu get-togethers.

It will be three long years before this great opportunity comes to the industry again—the opportunity not only to hear industry leaders spell out the latest in coal mining technology but to study a vast array of mining machinery and equipment. Don't miss Coal's big event for 1961!

PRELIMINARY PROGRAM

Monday Morning
Opening Session

Monday Afternoon
Open

Tuesday Morning
Strip Mining
Conventional Mining
Management & Cost Controls

Tuesday Afternoon
Haulage & Power
Cost Cutting—Industrial Minerals—Open Pit and Underground

Wednesday Morning
Open

Wednesday Afternoon
Coal Preparation
Strip Mining
Safety

Thursday Morning
Coal Preparation
New Mines

Thursday Afternoon
Continuous Mining

NEWS and views



Christmas Mine Progress

Shaft sinking progress continues to be made at Inspiration Consolidated Copper Company's Christmas (Ariz.) mine development project. The McDonald shaft has now been sunk 1140 ft, which leaves 640 ft to go, and a concrete-lined ventilation shaft, with a planned depth of 1205 ft, reached the 100-ft point recently.

The company reports that completion of preparatory work at the 1600-ft level of the development shaft will now permit use of highly mechanized equipment in driving the main haulage drifts from the ore body to the McDonald shaft. Hoisting and crushing equipment has been installed at the plant site, ore storage facilities are nearing completion and excavation has begun in the concentrator area. For the nine months ended September 30, development expenditures for the project were about $1,379,000. which compares with about $759,000 for the first nine months of 1959.

Merger Announced

Directors of Beryllium Resources, Inc. and Dynamic Metals Corp. have voted to merge the two companies. Beryllium Resources, which is to be the surviving company, is active in exploration and development of beryllium ores. Its principal activity at present is the development of a deposit in the Topaz Mountain area of Utah. Dynamic Metals has developed a new flotation process for the concentration of beryllium minerals, which is being tested in a pilot plant recently placed in operation at Los Angeles. All stock of Beryllium Resources will be owned by Brush Beryllium Co., Federal Resources Corp., Hidden Splendor Mining Co., and Edward Van Dornick, developer of the flotation process. President and chief executive officer of the surviving company will be Bruce W. Odlum.

1961 Meeting Cancelled

The Colorado Mining Association has announced that it will not put on the National Western Mining Conference in February 1961 because no substantial increase in aid could be expected from the Metal Mining Fund for assistance in putting on the conference. The two groups have in the past worked closely with each other, but over the last several months action has been taken to separate them. The Colorado Mining Association hopes to strengthen its organization during 1961 and hopes that some type of mining meeting can be held in the following years.

Beryllium Occurrences Reported

Two discoveries of beryllium occurrences were recently reported—one from Colorado and one from Idaho. The Colorado find, which is at the Redskin mine in Park County, is said to be yielding commercial ore. The Redskin, a one-time molybdenum producer, is under lease to U. S. Beryllium Corp., which operates the Boomer mine 2½ miles away. Ore occurs in an altered granite. The Idaho discovery is in the Yellow Jacket Mountains near Cobalt and about 80 miles north of an earlier one in the Sawtooth Mountains. While commercial quantities of beryllium mineralization were not apparent, the find was considered an important one that could lead to discoveries of commercial value in central Idaho. The mineralization was uncovered through a joint reconaissance project being conducted by the U. S. Bureau of Mines and the Idaho Bureau of Mines & Geology.

ALSO . . .

Fire recently destroyed the tungsten mill of Germania Consolidated Mines, Inc., located on the Spokane Indian Reservation near Hunters, Wash. Replacement cost is estimated at about $100,000. The mill suspended operations in 1957 due to a drop in tungsten ore prices.

A 1300-ft exploration tunnel is to be driven at the Creole mine near Minersville, Utah, according to plans of Index-Daley Mines Co. The work will be performed in an effort to intersect lead-zinc-silver mineralization showing on the surface and a fault which may contain ore.

Employes at the Kellogg, Idaho, operations of the Bunker Hill Co., which have been shutdown because of a strike since May 5, were slated to vote in a National Labor Relations Board representation election December 10. The recently organized Northwest Metal Workers Union is seeking to replace the International Union of Mine, Mill and Smelter Workers as bargaining agent for Bunker Hill employes, about 2200 of whom have been idle since the strike was called.

Alaska Portland Cement, Ltd., a California company, recently purchased a group of limestone claims from Alaska Limestone Co. in the Cantwell-Windy area about 165 miles north of Anchorage, Alaska. Substantial limestone reserves were said to be involved.

An option has been taken on 260 acres of claims near Fairfield, Idaho, by Boise Cascade Concrete, a subsidiary of Boise Cascade Corp. The claims will be core-drilled to establish the quantity and quality of pumice on them. If the deposits are developed, the pumice will be used as an additive in cement making.

A $500,000 silica sand beneficiation plant is being erected near Valley, Wash., by Lane Mountain Silica Co., which is owned principally by Northwestern Glass Co. and Del Monte Properties Co. The plant, incorporating facilities for crushing, milling, flotation, filtering and drying, is to be placed in operation this year.

Shaft sinking recently got under way at the Green River, Wyo., trona mining project of Stauffer Chemical Co. following completion of an access road to the property. The mine will have two shafts, one a haulageway shaft, the other a man-shaft. Stauffer plans to have the mine and refinery project completed and in full operation in late 1962. Initial capacity of the soda ash refinery will be 150,000 to 200,000 tons annually.

The Office of Minerals Exploration has authorized a $102,300 lead-zinc exploration project at the Marietta mine of Northern Mining & Milling Co., Inc., in Broadwater County, Mont. Cost of the project, which involves drifting and crosscutting work, will be borne half by the company and half by the Government. It is said to be one of the largest projects okayed by the OME since it succeeded the Defense Minerals Exploration Administration two years ago.

A proposal providing for the merger of Pacific Uranium Mines Co. into Kerr-McGee Oil Industries, Inc., will be voted upon by stockholders of the latter company at a special meeting to be held December 20. The merger would increase Kerr-McGee's interest in its subsidiary, Kermac Nuclear Fuels Corp., by 20 percent. Pacific Uranium, in addition to its holdings in Kermac Nuclear, owns other uranium mining property in the Ambrosia Lake district of New Mexico.

Development work at the Black Rock-Elm Orlu mine of the Anaconda Co. at Butte, Mont., is nearing completion, and it is expected that production of zinc ore will begin early in 1961. Ore will be hoisted through the nearby Badger shaft.

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- Form tubing used for fabrication of fittings to allow uniform flow.
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SFS-9

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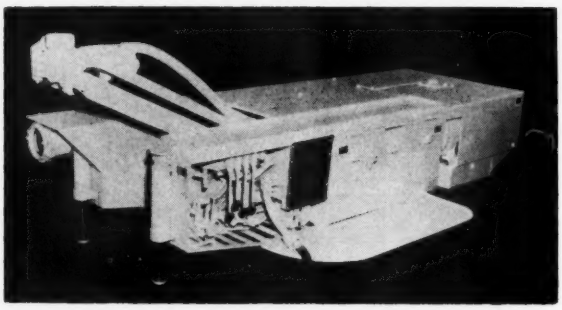
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto

In Canada: Stratoflex of Canada, Inc.

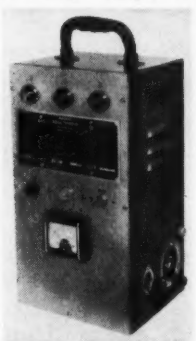
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manufacturers forum

A ROOF BOLTING MACHINE, Model LRB, recently developed by Long-Airdox Co., Oak Hill, W. Va., features one-man operation and a high degree of maneuverability. It is designed with variable drilling speed for different types of material and with a 42-in. lift. Maneuvering in narrow runways and close timbering is facilitated by its 40-in. width and ability to turn in its own length of 108-in. The unit is 27 in. high, trams at 140 fpm and can be furnished with a hydraulic face drill to permit roof and face to be drilled simultaneously.



A COMBINATION GROUND DETECTOR AND FAULT FINDER is available from Parr Mfg. Corp., 44 Austin St., Newark, N. J. Imposing only two amps in the circuit, it locates trouble on power systems, both a-c and d-c, up to 600 volts while the system is energized, thus alleviating production shutdown. Operated by one man, the Faultfinder is said to be convenient in detecting overhead cable, pipe and line signals and buried circuits without climbing or excavating. Weight of unit is 18 lbs, and includes a cabinet, exploring cord, extension pole, and double earphones.



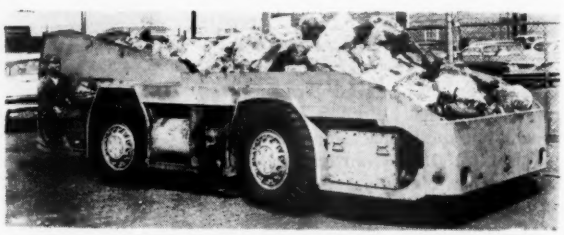
AN SRL PUMP WITH MOLDED SOFT RUBBER LINING and impeller, known as the "Tru-Glandless," has been released by Denver Equipment Co., 1400 17th St., P. O. Box 5268, Denver 17, Colo. It has no gland, the passage around the shaft sleeve is open to the atmosphere when the pump is operating, and when the pump is stopped a centrifugally operated seal is said to prevent leakage.

PORTABLE MOTOR TRUCK SCALES, recently announced by Toledo Scale Corp., Toledo 12, Ohio, are claimed to have major advantages in installation, portability and flexibility. They are self-contained units said to be readily moved over highway or by rail from one job site to another. They are of all-steel construction, and have an "Add-A-Unit" design enabling the user to add units to capacities up to 100 tons and platform lengths to 70 ft. The scales are offered in a wide range of capacity and platform lengths from 8 by 10 ft, 15-ton portable axle load units, to 70 by 12 ft, 100-ton tandem connected units.

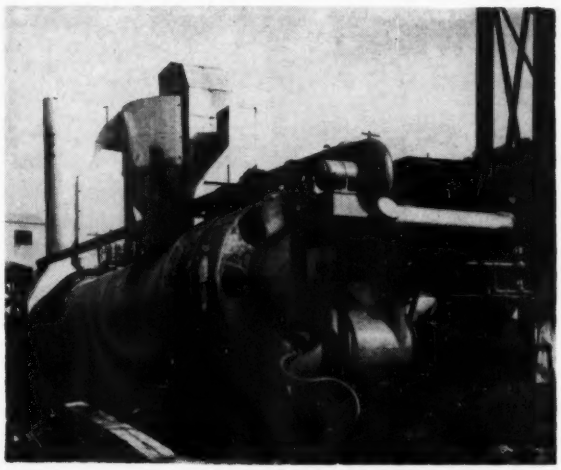
AN AIR BLEEDER VALVE FOR HYDRAULIC CIRCUITS has been developed by the Lenz Co., 3301 Lepinger Rd., Dayton 1, Ohio. The valve is designed to be installed at the highest point in the hydraulic circuit, the point at which air accumulates. It is compact in design, has only two metal parts, employs no packings, and is available in a range of popular sizes in cadmium plated steel, and, by special order, in stainless steel.

A HIGH TONNAGE MOBILE BELT LOADER, said to be capable of pouring 3500 tons of material per hr into hauling units, has been introduced by Western Conveyor Co., P. O. Box 357, Boise, Idaho. The company says that the unique features of the loader are a continuous running belt and internal hydraulically operated gate control and feeder. The positive hydraulic cut-off of the discharge gate and feeder prevents dribbling or spilling of materials between loading discharges, and the continuous running belt eliminates shear and starting load. The fifth wheel pin is located under the discharge end, thus permitting hook-up and movement by truck without crane lift or tractor pullout. The unit, equipped with tandem dual wheels to carry its 64,000 lb bulk, is hauled intact by standard hauling equipment.

AN A-C SHUTTLE CAR, offered by Goodman Mfg. Co., Chicago, Ill., has a basic height of 44 or 49 in. and a width of 96 or 106 in. It is capable of transporting 10 tons of coal or 13 tons of rock, a payload that can be increased with the addition of 6 or 12-in. sideboards. An 80-hp traction motor with two sets of windings provides for two-speed operation without use of clutches and torque converter, and permits use of simple electrical, mechanical and hydraulic systems. A 26-hp motor powers a mechanical conveyor drive and the hydraulic system. Planetary type wheel units lessen wear and strain on the entire tram mechanism and produce high torque at the wheel hub where it is needed for heavy duty service. The all welded body and reinforced frame are designed for rugged usage.



A HEAT DRYER capable of processing up to 200 tph of coal and operating on a reportedly new heating method has been introduced by Pritts Construction Co., P. O. Box 472, Scottdale, Pa. The new method consists of using the coal dust, normally carried off as waste, to generate the required heat. A pilot flame from natural gas or oil assures proper burning in the combustion chamber and safely from explosion. Coal is said to be kept in suspension long enough for heated air to evaporate the moisture and also cool the coal so the finished product is far below critical temperature, eliminating expensive coal fires. The Pritts dryer handles lump sizes to zero or slack. Operating and maintenance costs are claimed to be low since the unit uses waste coal dust for firing with a minimum of purchased fuel.

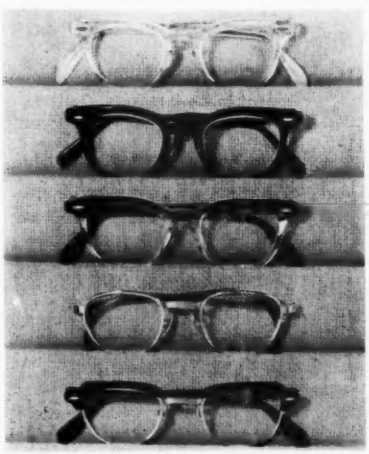


A BUBBLE GUN, capable of producing an "ocean of foam" within a matter of minutes has been produced by Safety Development Corp., Greensburg, Pa., primarily for use in fighting mine fires. The equipment generates 12,000 cu ft of foam per min and



drives it 2000 ft from the mouth of the machine. Known as the Hi-Ex system, it consists of a portable foam generator equipped with pleated nylon netting, nozzles and other accessories, and a proportioning pump assembly to mix a special foaming agent with water. Principle of the equipment has been explained as the rapid generation of high expansion foam having 1000 times the volume of the liquid in contrast to the conventional fire fighting foam with its 10-to-1 expansion ratio.

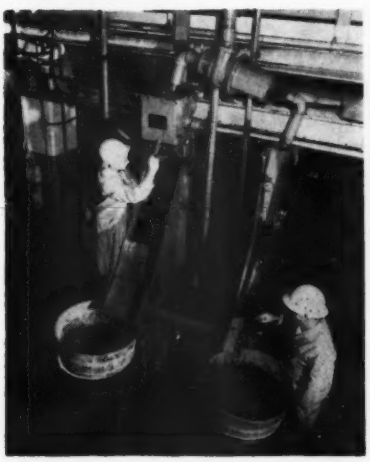
SAFETY EYEWEAR, combining maximum protection with the appearance of modern functional glasses, has been introduced by Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh 8, Pa. The Sightgard eyewear is designed for a variety of industrial applications, providing high optical quality and impact strength in excess of specifications. The line is available in metal and acetate frames, various temple styles, and rigid and adjustable nose pads. There are many types of lenses, covers and plates. These include clear lenses in the standard S-7 shape; lightweight plastic lenses where pitting is a problem; and ultra-filter lenses for protection against glare and impact. Round 50mm lenses and plates are also available for chipper and welder eye protection; for filtering of sodium glare; for protection against pitting and spattering; and for visual reading of melt condition in steel operations.



A NEW DENSE MEDIA PROCESS, announced by Dorr-Oliver Inc., Stamford, Conn., provides wet-cyclone beneficiation of 2½ in. by 65 M ore. The new process employs DorrClone cyclones as separatory vessels in the media cleaning circuit as well as heavy media ore classification units, utilizes DSM Screens for media draining and tramp service, and introduces the D-O SiphonSizer classifier in media recovery.

In the system, plus ¼-in. and minus ¼-in. feed are handled in separate circuits. Feed in both circuits is introduced to cyclones under a constant gravity head. Automatic control of the apex (underflow) discharge controls the effective separation gravity, compensating for feed variables. From this point on, the coarse and fine ore circuits differ materially, the coarse ore circuit following the conventional heavy media flowsheet.

The fine ore circuit, however, provides for separation of media from both tailings and concentrate by a DSM Screen. Oversize is sent to wash screens, from which it is sent to concentrate and tailing piles respectively. Wash screen undersize is classified in the cyclones, from which the coarse fraction (underflow) is magnetically separated and cleaned. Since the magnetic cleaning circuit handles only a small portion of the dirty media, separator efficiency is increased. Cyclone overflow is magnetically flocculated and hydraulically cleaned in the SiphonSizer, a new hindered-settling classifier featuring automatic discharge, no moving parts, and low pressure water operation. Its underflow is thickened for return to the heavy media circuit.



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MINING CONGRESS JOURNAL

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ANNOUNCEMENTS

Paul C. Manley has been appointed vice president and general manager for **Long-Airdox Co.,** Oak Hill, W. Va. and Chicago, Ill. Manley will supervise overall operations of the company and coordinate manufacturing activities of Long-Airdox plants in West Virginia, Pennsylvania, Iowa, and Illinois. He has been associated with the mining industry for 25 years and was named a vice president earlier this year when Airdox Cardox Products Co. merged with the Long Co. to form the Long-Airdox Co.



P. C. Manley



D. L. Boggs, Jr.

The company also announced the appointment, as southeastern sales representative, of **Delbert L. Boggs, Jr.,** who will headquarter in Birmingham and operate in Alabama and southeastern Tennessee. Boggs has been a mine foreman and mining engineer.

Hercules Powder Co., Wilmington, Del., has made announcements of new executive and managerial appointments. Elected as vice-presidents of the company are **Elmer F. Hinner** and **John M. Martin,** who were also made members of the company's executive committee. Hinner has been general manager of Hercules' Cellulose Products Dept. since 1954, and a member of the board of directors since 1952. Martin, a recognized authority in the high explosives field, has been general manager of the Explosives Dept. and a member of the board since 1952.

As general managers of two of Hercules' operating departments, **Werner C. Brown** and **Jack D. Hayes** succeed Hinner and Martin, respectively.

William L. Oliver, vice-chairman of the board since 1956, **Dorr-Oliver Inc.,** Stamford, Conn., has been elected chairman. Oliver, who also serves the company as general counsel, succeeds **J. Delano Hitch, Jr.,** who resigned earlier.

R. B. Hazard, vice-president and sales manager Rubber and Packings, **Raybestos-Manhattan, Inc.,** since 1956, was recently elected a director of the corporation. Starting in 1945 as a sales representative, Hazard has held a number of managerial posts with the company.

C. H. H. Weikel has been elected a vice president of **Bethlehem Steel Co.** He will head a newly created research department.



Howard C. Human has been appointed a sales engineer with **Goodman Mfg. Co.,** Chicago, Ill. Human has a long record of experience with major coal operating companies, most recently having been superintendent of the Glen Rodgers, W. Va. mine of Old Ben Coal Corp.

Joy Mfg. Co. has announced that all coal machinery sales in Montana, Wyoming, Utah, Colorado and New Mexico will be handled by **Schloss and Shubart, Inc.,** Denver. According to an agreement signed by the two organizations, Schloss & Shubart become exclusive sales agent for all Joy machines, accessories, and replacement parts in this territory.

Mine Safety Appliances Co. recently named **Richard E. Miller** product line manager for its eye and face protection equipment. Miller, who had previously been sales manager for Pennsylvania Optical Co., will supervise sales of Mine Safety's new line of spectacles, goggles, and face shields.

Steve G. Sutton, has been appointed manager of public relations, **The Jeffrey Manufacturing Co.,** Columbus, O., succeeding **L. H. McReynolds,** who is retiring after 40 years service. Sutton was graduated from Miami University, Oxford, O., where he majored in marketing and merchandising. He was with the sales department of Monsanto Chemical Co. before joining Jeffrey in 1957. He has been assistant manager of distributor sales for the past two years.

McReynolds has been advertising manager since 1953. Widely known in industrial advertising circles, he was director and past president of the Columbus chapter of the Association of Industrial Advertisers.

CATALOGS & BULLETINS

BLAST HOLE DRILLS AND STATIONARY COMPRESSORS. *Sales Promotion, Dept. CG-15, Le Roi Div., Westinghouse Air Brake Co., Sidney, Ohio.* "Products for the Construction Industry" includes information on the "Trac-Newmatic," a self-propelled blast-hole drill, as well as specifications for Le Roi stationary compressors from 25 to 100 horsepower. The dust collector and line oiler as well as the portable and Tractair compressor line are also discussed together with a line of air tools.

TESTING SIEVES. *The W. S. Tyler Co., 3615 Superior Ave., Cleveland 14, Ohio.* Bulletin 608, describes testing sieves made by Tyler to the 1960 revised specifications embodied in A. S. T. M. specifications E–11–60–T. Also listed are specifications being proposed as International Standards. The new specifications combine the former coarse and fine series into a single series. Wire diameters are specified to produce a progressive relationship between sieve openings and wire diameters throughout the entire series. While screen openings are compatible with the old National Bureau of Standards series and A. S. T. M. specification E–11–39, manufacturing tolerances have been revised to produce sieves of greater accuracy and consistency of results, according to Tyler.

LEAD ORE PULP DENSITY CONTROL. *Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.* A new 8½ by 11 illustrated process application sheet, No. Q12–2, is available, which describes the operation of a Bailey lead ore pulp density control system for obtaining more uniform operation and more uniform particle sizing. Two recorder charts illustrate the difference in operation between manual control and automatic control. A simplified diagram of the pulp density control system is also shown.

CUTTER BITS. *Kennametal Inc., Mining Tool Div., Bedford, Pa.* Catalog M-10 includes many styles of cutter bits not mentioned in previous Kennametal bulletins. Included in this bulletin are shank styles in the U7 series, the U16 for boring-type continuous miners, a U15 series with side shoulders similar to those on Style J2 bits, and the heavy-duty U17 series bits with new gage shoulder location. Revisions and rearrangement of specifications also have been made on rotary drill bits, roof bits and augers, auger adapters, core bits, and finger bits. A section dealing with wear proofing illustrates cemented carbide inserts and blanks, and methods of applying Kenface tungsten carbide hard facing.

REVOLVER FEEDERS. *Fuller Co., Catasauqua, Pa.* Described in this bulletin are "blow through type" revolver feeders designed for feeding dry, pulverized, and granular materials into high pressure pneumatic conveying systems with small diameter lines. These feeders are used with pressure systems of either high or low velocity types, and provide a compact unit requiring less headroom than other types. Included are photographs and dimensions.

(Continued on next page)

(*Continued from previous page*)

SECONDARY CRUSHER. *Allis-Chalmers, Milwaukee 1, Wis.* Bulletin 17B9746 describes the 16–50 Superior secondary crusher designed to handle the full output of a 42 by 54 single toggle or a 42 by 48 A-1 jaw crusher. Features of the 16–50 crusher include a 16 in. feed opening; 50 in. diam crushing cone; choice of three eccentric throws; and vertical shaft adjustment through Hydroset control, which compensates for wear, quickly makes settings, and permits start up under load after power failures.

VACUUM DISC FILTERS. *Filtration Engineers, a division of American Machine and Metals, Inc., East Moline, Ill.* Diagrams and photographs of the FEinc disc filter, along with a chart showing their area in sq ft, included in this bulletin. Also discussed are details about the fabricated manifold, agitation methods available, and especially mounted scraper blades to minimize bag wear.

TRACTOR LINE. *Construction Machinery Div., Clark Equipment Co., Pipestone Plant, Benton Harbor, Mich.* Bulletin 150A describes and illustrates the complete line of the company's tractor shovels, tractor dozers, tractor scrapers, tractor loggers, and excavator cranes. This is the first Michigan general catalog to show the 600 hp Michigan Model 480 Tractor Dozer and Models 55A, 55B and 85A in the tractor shovel line. Many of the illustrations are on-the-job photographs of these vehicles in operation.

JET CLEANER. *Sellers Injector Corp., 1600 Hamilton St., Philadelphia 30, Pa.* Bulletin 446 contains information on the installation, operation and maintenance of the Sellers "Super Booster" hydraulic jet cleaner, which the company has developed and claims is the "most powerful jet tool" in its line of cleaning equipment. This newly patented unit uses steam as its source of energy in a unique venturi injector assembly which combines it with water and detergent, under high pressure, to form a discharge stream that removes dirt, grease or grime from walls, floors, equipment and machinery.

ROTATING DISCS. *Materials Handling Dept., Dravo Corp., Neville Island, Pittsburgh 25, Pa.* Bulletin No. 247, "Dravo Pelletizing and Mixing Discs," cites design features and advantages of the company's discs, which range in diameter from 39 in. to 16 ft 5 in., and lists typical capacities. Stressed are: the classifying action of the disc in producing pellets of uniform size; the high output of the disc through continuous operation; the adjustibility of plows, pan angle, and rotating speed; the quality of pellets produced; the infrequent necessity for binders; and the overall cost per ton of output.

ROCK CRUSHER. *The Frog, Switch and Manufacturing Co., P. O. Box 431, Carlisle, Pa.* This bulletin describes "Pulvo-Matic" a rock crusher with only one moving part. Its cast managanese-steel rotor cage works in conjunction with managanese-steel liner plates to reduce rock products, coal, etc., to graded sizes. Bulletin cites advantages of this engineering principle—uniformly sized and more cubical aggregate, control of aggregate size through control of rotor speed, power savings and low maintenance expenses. Approximate weight, required space and approximate horsepower are given for three crusher sizes.

SCREEN HEATER. *The Deister Concentrator Co., Inc., 901–935 Glasgow Ave., Ft. Wayne, Ind.* Bulletin 16-EH describes the Leahy Heavy Duty Model E Vibrating Screen with FlexElex Screen Heater. Listed are features of this equipment plus a data sheet, types and sizes.

SPEED DRIVES. *General Electric Co., Schenectady 5, N. Y.* GEA-6806 describes the new ¼ – 25 hp line of Polydyne mechanical adjustable speed drives introduced by General Electric. Bulletin discusses principles of operation, configuration and features, and includes mounting positions, rating tables, and description of available accessories. Also discussed: the benefits of mechanical adjustable speed drives and how to select and specify Polydyne units.

COAL AND MINERAL FLOTATION. *WEMCO, Division of Western Machinery Co., Sales Promotion Dept., 650 Fifth St., San Francisco 7, Calif.* WEMCO has released bulletins F5-B37, describing the principle and use of fine coal flotation cells, and F5-B32, describing the principle of flotation process for selectively separating finely divided mineral particles. Featured in bulletin F5-B37 are flowsheets and results when treating plant overflow and plant blackwater. Design and construction details and operating characteristics of WEMCO's Fagergren flotation cells are covered in F5-B32.

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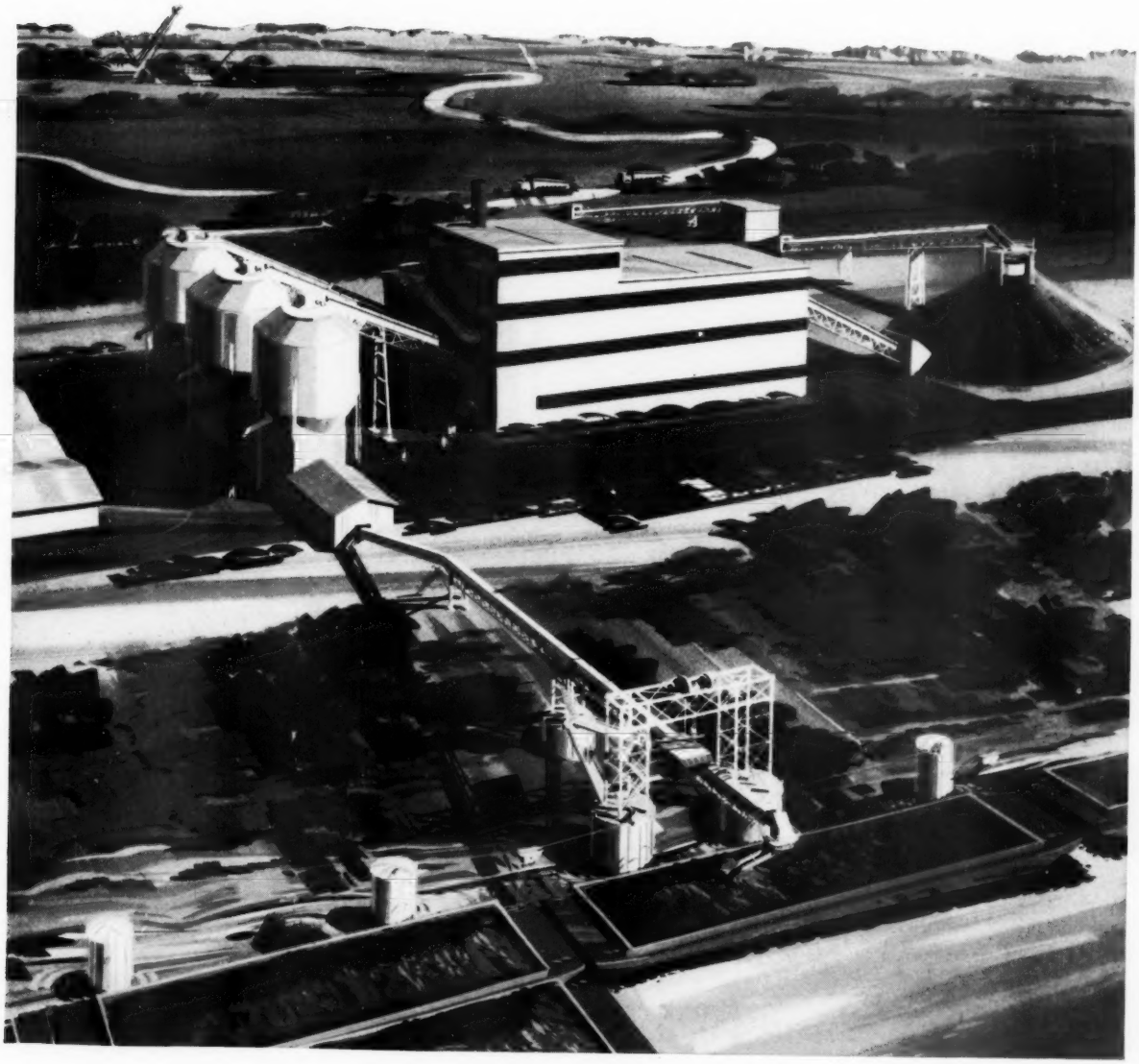
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new modern direct barge-loading coal mine

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Here, the THRU-STEEL Dust Collector is mounted on a continuous miner. Roof bolt drills and dust collectors on both sides of the machine help keep roof bolting up to or ahead of the miner.

For maximum efficiency

New M-S-A® Collector sucks dust through drill steel —speeds roof bolting, improves safety

The M-S-A® THRU-STEEL* Dust Collector helps keep roof bolting up to or ahead of the mining cycle.

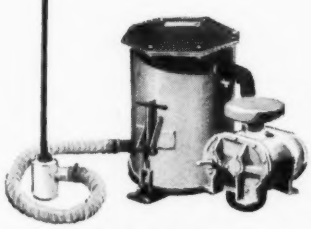
With old style collectors, time wasting set-ups are necessary to raise the dust collecting head against the roof. Not so with THRU-STEEL Collector. Collector cup and jack assembly are eliminated. Dust is sucked into the tubular drill steel through narrow slots below the bit, and quickly conveyed through the drill steel to the collecting tank. Smooth round drill steel, used with this system, is easier to handle than scrolled augers. Steels can be added and withdrawn easier, faster, and more efficiently.

THRU-STEEL Collector assures safe, proper dust control because bolt hole drilling and dust collecting operations are integrated. Cleaner, safer working conditions, with better visibility result. Drill steels are safer to handle. No scrolls to snag gloves, sleeves, or clothing.

The M-S-A® THRU-STEEL Dust Collector installs on any roof bolting machine or continuous miner equipped with roof drills. Various lengths of drill steel make it adaptable for high or low seams. If you have the M-S-A® Bolt-Hole Cleaner, it can be converted to a THRU-STEEL Collector easily, inexpensively. Call your MSA Representative for all the facts, or write us for bulletin.

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This is the THRU-STEEL system. It consists of the bit, drill steel, chuck adaptor, rectangular or cylindrical collecting tank, vacuum pump, relief valve, and silencer.
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